I. C. 6687

FEBRUARY, 1933

DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
SCOTT TURNER, DIRECTOR

INFORMATION CIRCULAR

GROWTH AND DEVELOPMENT OF THE NONMETALLIC MINERAL INDUSTRIES

BY

OLIVER BOWLES AND C. W. JUSTICE

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By Oliver Bowles[2] and C. W. Justice[3]

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6687."

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INTRODUCTION

A conviction is growing that depressions and other adverse conditions are not entirely unavoidable if a knowledge of past achievements and shortcomings is intelligently applied in shaping the course of industry. Mineral producers have available a source of such knowledge concerning their industry in the statistical records of the United States Bureau of Mines, and by scanning this increasingly exact history can obtain information on which to found a more stable future.

This paper contains a brief history, covering more than 50 years, of the activities of the nonmetallic mineral industries as a group, followed by short histories of each of the more important commodities in which are noted the circumstances that have influenced their development.

Helpful service has been rendered by Paul M. Tyler, H. Herbert Hughes, and Paul Hatmaker, of the Bureau of Mines, in the preparation of charts and the assembling and interpreting of economic data.

MAJOR MINERAL GROUPS

Mineral commodities produced in the United States may be divided into three major groups: Nonmetals, metals, and fuels. Of the total production value, mineral fuels (coal, oil, and gas) account for more than one-half; the remainder is about equally divided between metals and nonmetals, sometimes one and sometimes the other being ahead, although the tendency has been for the nonmetals to gain faster than the metal group. In 1930 the value of mineral fuels produced in the United States was estimated at $2,764,500,000, the value of metals at $986,975,000, and the value of the nonmetals at $1,013,325,000. In value of production, therefore, the nonmetals exceeded the metals by a considerable margin in 1930. Under the abnormal conditions of 1931 the total values of all groups were greatly reduced, but the nonmetals attained a high relative level, exceeding the metals by nearly 30 per cent.

RAPID GROWTH OF NONMETALS

Even in prehistoric times several nonmetallic minerals were exploited. "The stone age" is the descriptive name for the period when the implements and weapons employed by primitive men were of stone and their habitations were rock caves. Clay has always been readily available and was extensively used long before the discovery of the hardening effect of heat, the adobe construction of ancient times persisting in some regions to the present day. Ocher and other natural pigments found use as Indian war and ceremonial paint ages before white men entered America. Mica, for undiscovered uses, was mined in North Carolina by the mound builders.

Other examples of the use of nonmetallic minerals and rocks in human activities in remote ages could doubtless be mentioned, but actually the development of the nonmetallic mineral industries on an industrial scale is comparatively recent. While production records for silver, gold, and some other metals have been compiled over periods of several centuries, the nonmetals were of so little importance in early years that very few statistics exist for years prior to 1880, and the records for that year indicate that most of these industries were then practically in their infancy. The twentyfold increase in production value from $56,000,000 in 1880 to more than $1,200,000,000 in 1929 sufficiently indicates the rapidity with which these great industries have subsequently become enlarged to vital parts of the country's manufacturing and commercial activity. During the same 50-year period there has been an equally remarkable growth in mineral-fuel production, which registered a twenty-sixfold increase, while the value of metal production has increased about eightfold.

SIZE CLASSIFICATION OF THE NONMETALLIC MINERAL INDUSTRIES

The nonmetallic mineral industries (exclusive of the fuels industry) to which consideration is given herein provide materials that are of tremendous importance to modern civilization. The major industries of this class, each exceeding one hundred million dollars in annual production value, are those which furnish clay products, cement, stone (including slate), and sand and gravel. These four basic industries had a total production value in 1930 of over eight hundred million dollars, accounting for about 80 per cent of the total nonmetallic mineral value.

The intermediate group of industries, having annual production values ranging from ten million to fifty million dollars, includes sulphur and pyrite, lime, gypsum, salt, and phosphate rock. The production value of this group is about 13 per cent of the total.

A third group of industries, each with an annual production value of less than ten million dollars, produces 20 to 30 minerals or their primary products, the aggregate output of which represents less than 7 per cent of the total value of the nonmetallic mineral production. The more important of these minerals, to which individual consideration is given on later pages, are abrasives, asbestos, barite, diatomite and tripoli, feldspar, fluorspar, fuller's earth, graphite, magnesite, mica, potash salts, and talc and soapstone.

INDUSTRIAL DEMANDS FOR NONMETALLIC MINERALS BY GROUPS

The first group of nonmetallic minerals, is related almost exclusively to the construction industries. Brick and tile, the chief clay products, are used mainly in building construction and paving. Nearly all of the cement produced is used in the building trades, highway construction, and in public works. Dimension stone, although employed to some extent for memorials, is preeminently a material of construction. Crushed stone is used as railroad ballast or in road building, and is a companion material to cement in concrete aggregate. Gravel is employed in much the same way as crushed stone. Sand is used not only for concrete but also for other building and paving uses, and has a multitude of lesser applications. The minerals in this group owe their growth and development to the intensive construction of all types that has characterized recent years, and their future prosperity depends almost entirely on continued activity in the construction field.

Of the second group, gypsum is primarily a material of construction. About 40 per cent of all lime produced is used as a building material and the other 60 per cent enters the chemical industries and agriculture in the proportion of about 5 to 1. Phosphate rock is used almost exclusively (over 90 per cent) as a fertilizer. Salt (sodium chloride) and sulphur are employed chiefly as chemicals in manufacturing processes. This intermediate group, therefore, is divided mainly among the building trades, chemical industries, and agriculture.

From a study of mere figures the third group of minerals might be dismissed as of relatively small significance because the aggregate annual value of the 12 more important commodities to which individual consideration is given on later pages amounts to less than 2 per cent of the total value of the nonmetals. It is a noteworthy fact, however, that several minerals of this third group are regarded as absolutely essential to modern industry. While their value may not exceed a few hundred thousand dollars a year, no amount of money could produce satisfactory substitutes were the supply of these key minerals cut off. Asbestos is as vital to the manufacture of automobile brake bands as are stone, sand and gravel, and cement for the construction of the roads over which the automobile is designed to travel. Our vast electrical industries could not approach their present magnitude or degree of efficiency without mica. Feldspar and china clay are deemed essential to pottery manufacture. Much unsuccessful effort has been expended in seeking a substitute for fluorspar in steel metallurgy. The clarification of mineral and vegetable oils requires fuller's earth, diatomite, or similar minerals, and no substitutes have yet been found. Nothing takes the place of graphite for crucible manufacture where high temperatures are involved, and magnetsite refractories are now regarded as essential to metallurgical practice.

Even a casual study will indicate the vast importance of nonmetallic minerals in modern life. It is obvious that the construction of buildings, highways, railroads, dams, and bridges would be paralyzed were it not for stone, sand and gravel, cement, lime, gypsum, and ceramic products. The essential nature of lime, sulphur, and salt in hundreds of chemical industries is generally recognized. Lime is called "the king of all the bases," and trade in sulphuric acid has become an industrial barometer. Without limestone, lime, gypsum, phosphate rock, nitrates, or potash, impoverishment of the soil would soon result in national disaster.

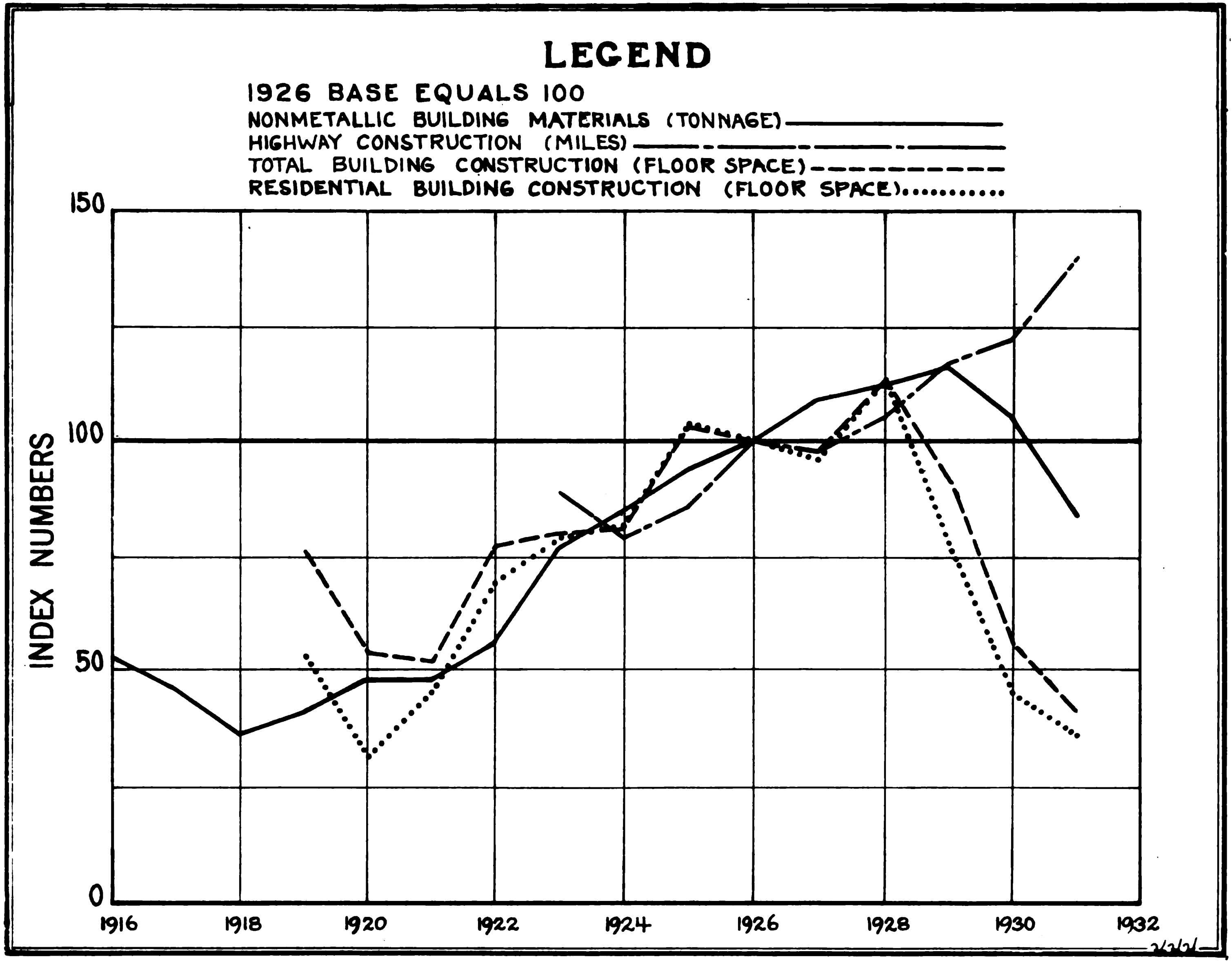

Figure 1.—Construction indexes

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In view of the enormous demand for the basic materials of construction and the peculiar properties of many minerals that adapt them for highly specialized uses although in comparatively small quantities, it is not surprising that growth in production of most of the nonmetallic minerals has been phenomenal.

RELATION OF CERTAIN NONMETALS TO CONSTRUCTION INDUSTRIES

As stated previously, the major groups of the nonmetals are used chiefly as materials of construction. Figure 1 illustrates the relation of shipments of a group of nonmetallic building materials to total building, residential building, and highway construction for a period of years subsequent to the World War. The materials represented in this chart are cement, crushed stone, sand and gravel, gypsum, and lime. The weighted index therefor was compiled by the Bureau of Mines. Data for building construction are in terms of contracts awarded as reported in publications of the F. W. Dodge Corporation, and figures for highway construction have been obtained from the Bureau of Public Roads of the Department of Agriculture. It is important to note that all the indexes plotted in Figure 1 are based on quantities, not values.

Restrictions imposed on building during the war resulted in a reduced volume of total construction which, as indicated on the chart, reached a low point in 1921, although residential construction was already well on its way toward recovery. Stimulated largely by the accumulated shortage of housing, an era of active building characterized the years 1922 to 1928, after which a precipitous decline took place, the initial drop being due mainly to the sharp recession in residential construction. Highway construction data from 1923 indicate a decline in activity in 1924, followed by a strong upward trend.

It may be observed from this chart that the curve for building materials tends to lag behind that for the construction industries, and responds slowly to changes in building activity. Thus a sudden boom in building-contract awards is followed by a more gradual increase in shipments of building materials; similarly, when a pronounced recession in new contracts occurs the mineral industries continue for a time to furnish material for the uncompleted contracts. These lags are noticeable on the chart for the years 1920, 1922, 1924, 1925, 1927, and 1929. The mineral-products curve, moreover, shows smaller fluctuations from year to year than either the building-contracts or highway-construction curve.

For the period following 1928 the shipments of nonmetallic building materials declined greatly, despite the great expansion in highway construction. The inability of extensive highway work to stem the downward trend emphasizes the dominance of building, especially residential building, in the prosperity of this important group of the nonmetallic mineral industries.

Table 1.- Value of mineral production in the United States, 1880 to 1931

Year	Nonmetals	Metals	Mineral fuels
1880	$ 56,340,966	$ 190,881,000	$ 120,241,034
1881	60,659,281	192,663,000	149,797,719
1882	63,557,254	219,070,000	170,478,746
1883	61,169,893	201,131,000	185,760,107
1884	58,431,456	182,784,000	165,824,544
1885	61,757,961	174,718,000	183,075,039
1886	66,781,511	204,795,000	184,608,489
1887	77,198,069	241,183,500	217,251,431
1888	79,880,493	242,460,000	231,458,507
1889	83,205,738	250,823,500	208,296,762
1890	80,529,597	303,937,000	230,962,403
1891	82,704,228	280,985,000	237,159,772
1892	89,673,442	284,215,000	248,343,558
1893	70,103,728	223,654,000	251,735,272
1894	127.291,941	187,335,000	235,618,059
1895	125,720,011	248,533,000	268,437,989
1896	120,304,613	252,575,000	268,161,387
1897	127,580,328	270,434,000	253,597,672
1898	150,781,578	308,747,000	267,513,422
1899	185,301,989	484,021,000	340,773,011
1900	188,327,849	514,232,000	406,376,151
1901	218,854,519	493,814,000	442,409,481
1902	253,855,158	605,017,000	469,078,842
1903	271,901,709	589,253,000	634,226,291
1904	373,823,764	501,314,000	584,043,236
1905	318,722,452	702,785,000	602,257,548
1906	362,201,524	886,280,000	652,398,476
1907	376,290,954	904,151,000	789,128,046
1908	324,849,325	550,890,000	716,033,675
1909	385,810,708	755,092,500	746,203,792
1910	409,603,633	750,027,500	828,212,867
1911	407,826,503	681,023,000	835,231,497
1912	431,219,725	862,191,000	944,383,275
1913	469,102,856	879,058,000	1,085,384,144
1914	434,566,618	686,874,000	989,731,382
1915	434,232,543	992,945,000	967,466,457
1916	553,469,378	1,622,385,500	1,332,584,122
1917	665,525,000	2,089,134,000	2,237,837,000
1918	647,889,000	2,156,668,000	2,736,151,000
1919	751,832,000	1,361,444,000	2,482,494,000
1920	1,023,670,000	1,764,760,000	4,192,910,000
1921	779,575,000	655,455,000	2,703,470,000
1922	920,380,000	989,030,000	2,737,880,000
1923	1,156,495,000	1,512,905,000	3,317,100,000
1924	1,171,970,000	1,235,200,000	2,898,630,000
1925	1,235,545,000	1,383,405,000	3,058,680,000
1926	1,264,964,000	1,406,720,000	3,541,916,000
1927	1,248,153,000	1,221,800,000	3,060,047,000
1928	1,211,158,000	1,289,080,000	2,884,962,000
1929	1,215,568,000	1,481,205,000	3,190,527,000
1930	1,013,325,000	986,975,000	2,764,500,000
1931 1/	723,350,000	570,850,000	1,885,800,000

1/ Estimated.

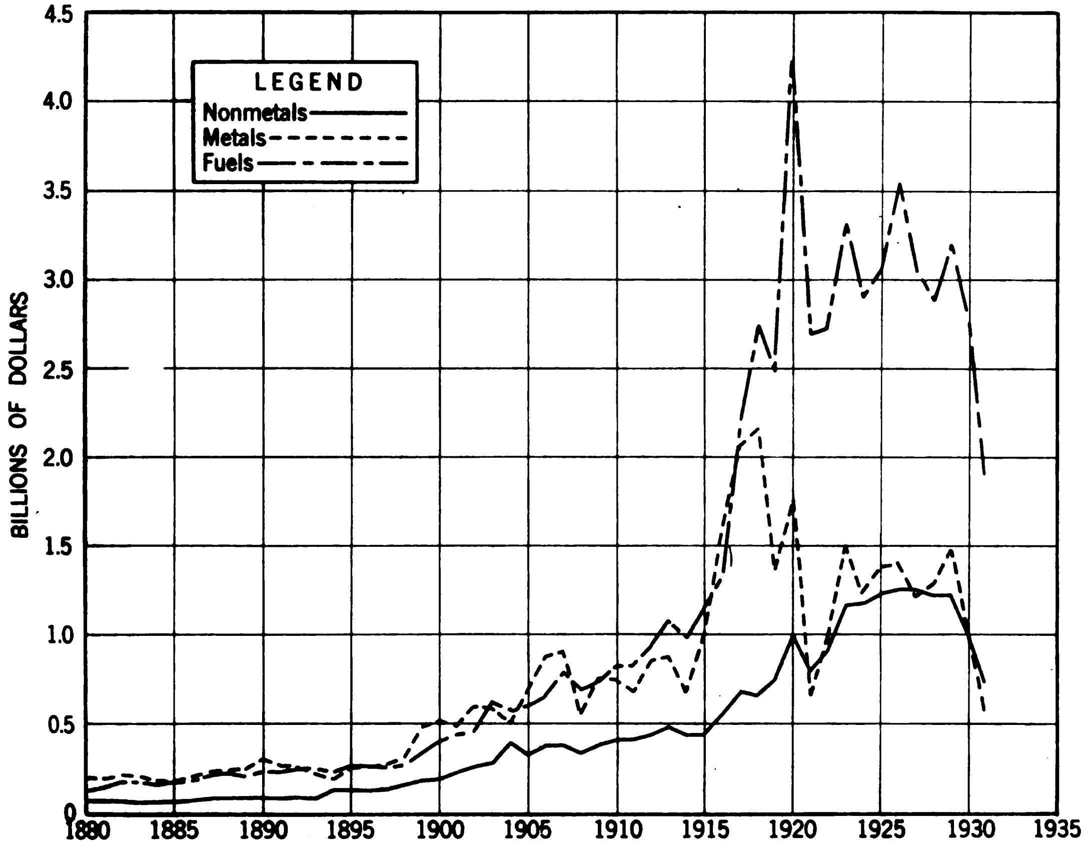

Figure 2.—Mineral production of the United States, 1880-1931

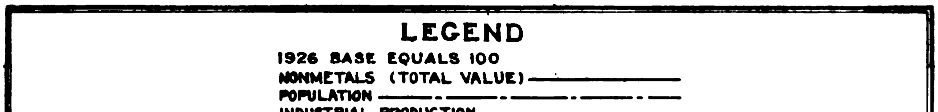

Figure 3.—Comparative indexes

STATISTICAL RECORDS

From reports of the U. S. Geological Survey and the U. S. Bureau of Mines figures for the total value of production of nonmetals, metals, and fuels have been compiled for the years 1880 to 1931, inclusive as shown in Table 1. The figures for nonmetals and metals do not agree with those given in the summarized tables in the Mineral Resources volumes because the values of unspecified items have been distributed, one-half being added to each of the major groups.

Curves plotted in Figure 2, based on these figures, show in more graphic form the growth of these three great branches of the mineral industries. As may be seen both metals and fuels were industries of considerable magnitude in 1880, while the nonmetals were of comparatively small importance. Until 1915 the growth of the nonmetals was gradual and fairly uniform. Both metals and fuels increased in value somewhat more rapidly, and with much greater fluctuations from year to year. The high peaks for metals and fuels during and immediately after the World War were due in some measure to increased production but largely to the extraordinary increases in prices. The lag in growth of the nonmetals during the war years as compared with metals and fuels was due to the nonessential character, from a war standpoint, of some of the important commodities used in building construction--notably stone, sand and gravel, lime, gypsum and cement. The 1921 reaction was more pronounced in both metals and fuels than it was in nonmetals, and in that year for the first time in history the annual value of production of nonmetals exceeded that of the metals.

From 1923 until 1930 the value of production of nonmetals was higher than it was during or previous to the World War period, and, as in 1921, it exceeded the value of metal production in 1927, 1930, and 1931. The recent business depression made its influence felt on the nonmetals in 1928, two years before the effects were apparent on metallic products.

It is evident from this chart that the nonmetallic mineral industries have as a whole experienced a healthy growth, with little fluctuation, to a maximum annual value of well over a billion dollars. The only serious recessions have been during the slump of 1921 and the more profound depression that began in 1929.

COMPARATIVE INDEXES

The increasing complexity of modern life, and the change from an essentially agrarian to an urban economy are reflected in a relatively rapid increase in general industrial production as compared with growth in population in the United States. The trend of this condition is plotted in Figure 3. Against this background are also plotted the wholesale price index of commodities in general, and the value of nonmetallic mineral production. It may be observed that the latter curve has tended to overtake the curve representing industrial production and, consequently has gained even more rapidly with respect to growth in population. In other words, the per capita consumption of nonmetals

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in the United States has grown faster even than the per capita consumption of industrial products in general.

In this chart the figures for the industrial production index are those compiled by the Standard Statistics Co., and those for the wholesale commodity price index are from the United States Bureau of Labor Statistics. The value of production of nonmetallic minerals was compiled from statistics of the U. S. Bureau of Mines and the U. S. Geological Survey.

A careful study of the curve for nonmetals indicates that it may be divided into four parts. During the first period, 1885 to 1893, it rises relatively slowly. During the second period, 1893 to 1915, the average increase follows parallel with the increase in population. The third period, 1915 to 1926, is one of extraordinary growth, reaching a climax in 1926. It was during this period that the nonmetals made their greatest gains relative to population and general industrial production, both of which were likewise on the uptrend. Then followed two years of hesitation ushering in the fourth period which is characterized by a sharp decline beginning in 1929, becoming more pronounced throughout 1930 and 1931, and (according to preliminary data) continuing during 1932. Whereas during the previous period the production value of the nonmetals was gaining on general production (as well as on population) the aggregate receipts of the nonmetallic mineral industries began definitely to drop off at least two years before the general depression engulfed all industries. The initial break in value of production in 1927, it may be noted, was the result of price declines, for the physical volume of production of most of the nonmetals continued to increase for a year or two -- without, however, showing the corresponding increment in aggregate value enjoyed by industry in general which, recovering from a slight recession in 1927, rose to its maximum in 1929.

DISCUSSION OF INDIVIDUAL COMMODITIES

The growth and development of the principal individual commodities are briefly outlined on the following pages. Attention is directed primarily to changes or trends in development and use, and to the controlling influences that have modified progress from year to year.

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Table 2.- Production value of major nonmetals, 1880 to 1931
(Recent annual production over $100,000,000)

Year	Clay products	Cement	Stone (including slate)	Sand and gravel
1880 ..	$32,833,587	$ 1,852,707	$22,156,055	-
1881 ..	-	2,529,000	24,100,000	-
1882 ..	-	3,672,750	23,310,000	-
1883 ..	-	4,293,500	21,907,136	-
1884 ..	-	3,720,000	20,700,965	-
1885 ..	35,000,000	3,492,500	20,678,478	-
1886 ..	-	3,990,000	21,830,297	-
1887 ..	47,000,000	5,674,377	28,236,517	-
1888 ..	48,000,000	5,021,139	28,772,440	-
1889 ..	-	5,202,951	46,408,293	-
1890 ..	-	4,526,551	53,035,620	-
1891 ..	-	4,638,826	47,294,746	-
1892 ..	-	5,144,055	48,706,625	-
1893 ..	67,900,000	4,409,895	33,885,573	-
1894 ..	64,655,385	5,019,204	30,096,242	-
1895 ..	65,409,806	5,482,254	29,354,283	-
1896 ..	63,110,408	6,485,463	26,711,434	-
1897 ..	62,359,991	8,226,783	30,419,013	-
1898 ..	74,487,680	10,057,551	32,358,715	-
1899 ..	95,797,370	13,157,142	39,207,450	-
1900 ..	96,212,345	13,283,581	41,211,243	-
1901 ..	110,211,587	15,786,789	52,071,708	-
1902 ..	122,169,531	25,366,380	60,494,733	$ 1,423,614
1903 ..	131,062,421	31,931,341	63,690,026	1,831,210
1904 ..	131,023,248	26,031,920	64,382,910	5,748,099
1905 ..	149,697,188	35,931,533	69,294,955	11,223,645
1906 ..	161,032,722	55,302,277	72,047,140	12,698,208
1907 ..	158,942,369	55,903,851	77,125,025	14,492,069
1908 ..	133,197,762	44,477,656	72,029,316	13,270,032
1909 ..	166,321,213	53,610,563	76,786,617	18,336,990
1910 ..	170,115,974	68,752,092	82,757,343	21,037,630
1911 ..	162,236,181	66,705,136	82,836,586	21,158,583
1912 ..	172,811,275	69,554,385	84,236,538	23,113,208
1913 ..	181,289,132	89,550,527	89,908,471	24,217,508
1914 ..	164,986,983	80,533,203	83,250,890	23,846,999
1915 ..	163,120,232	75,155,102	79,554,267	23,121,617
1916 ..	207,260,091	104,689,090	84,408,520	29,809,995
1917 ..	248,023,368	123,210,458	87,965,637	35,296,932
1918 ..	220,573,493	113,554,854	86,739,200	37,927,079
1919 ..	260,790,000	147,318,398	99,530,648	45,951,556
1920 ..	373,670,102	195,589,915	142,268,402	65,661,605
1921 ..	270,397,754	181,675,440	114,284,272	56,484,245
1922 ..	321,494,403	208,464,028	131,243,712	64,617,664
1923 ..	424,582,628	259,631,776	172,023,865	90,903,654
1924 ..	415,779,378	266,053,267	173,646,129	97,013,115
1925 ..	423,446,917	281,075,691	186,792,118	107,542,123
1926 ..	430,428,494	280,785,583	200,661,357	111,338,701
1927 ..	403,363,270	281,735,676	210,027,958	115,529,786
1928 ..	373,550,882	278,883,042	208,292,988	119,207,937
1929 ..	373,409,391	255,104,506	213,937,940	132,835,979
1930 ..	275,134,322	231,249,287	186,860,229	115,176,543
1931 ..	(1)	142,528,789	136,746,336	86,280,320

1/ Not yet available from Census Bureau.

Clay Products

Clay was used long before the hardening effect on it of heat was recognized. When it was found that clay baked by fire was much superior to that dried by the sun, the uses of clay multiplied. Both utensils of many sorts and various forms of ornamental pottery were manufactured by many ancient races. Clay was used for brickmaking by the Egyptians. The Indians of America used baked-clay pipes and utensils, and they employed red and yellow clays for ceremonial and war paint.

Bricks were brought in sailing vessels from England for the construction of some early colonial buildings, but suitable local clays were utilized for brickmaking, chiefly for chimney construction, soon after the first settlements were established. Bricklayers were among the first settlers of Jamestown, Va., in 1607.

Clays of some sort occur in great abundance in practically every State; they were utilized by the pioneers and from their time onward as the most available fireproof building materials. Thus the clay products industries grew rapidly and attained great importance long before most of the nonmetals found commercial use. The census of 1880 gave a production value of nearly $33,000,000. A great variety of products was made at this date, including building materials (common, face, pressed and glazed brick, hollow tile, roofing tile, and terra cotta) refractories, pottery, and miscellaneous products such as sewer pipe, drain tile, and flower pots. The products multiplied in number with the passing years, and their value increased to a maximum of more than $430,000,000 in 1926. Thus clay products as a group constitute the greatest nonmetallic mineral industry exclusive of fuels. As may be noted in Table 2, growth has been fairly uniform with the exception of a recession in 1908, again during the World War period when restrictions were imposed on the production of building materials, and a third notable recession in 1931. Clay products are made in every State, but the leading producers are Ohio, New Jersey, Illinois, Indiana, Missouri, and California. Their manufacture is influenced chiefly by the volume of building construction.

Fire-brick manufacture is an important branch that is dependent chiefly upon the metallurgical industries, and has developed parallel with them. The principal sources of fire clay are in Pennsylvania, Missouri, Ohio, Indiana, Illinois, New Jersey and California.

The first American pottery plant was erected about 1640 in New York City which was then under Dutch rule. About 1780 small potteries were operated at Trenton, N.J., Philadelphia, Pa., and in South Carolina. Trenton, N.J., and East Liverpool, Ohio, became the centers of pottery manufacture many years ago and have never lost their supremacy. The United States pottery industry received its first great impetus through the Centennial Exposition of 1876.

For many years American potters depended almost entirely upon English china clays, and even to-day large supplies are still imported for both ceramic and paper manufacture. It has been established, however, that high-grade kaolins are abundant in the United States, and they are more and more widely used. Certain grades of chinaware in which native kaolins are employed compare favorably with the best of the long-established imported products. High-grade kaolins have attained their greatest development in Georgia, South Carolina, North Carolina, Florida, and Pennsylvania.

One of the greatest hindrances to a wider use of domestic clays has been a lack of constancy in composition and properties as compared with imported china clays. This difficulty is gradually being overcome by improvement in mining and in processes of purification and treatment.

Cement

The earliest cement known, a type still designated as "puzzolana," was made by the ancient Romans by mixing powdered volcanic ash with quicklime. It was a hydraulic cement; that is, it would set under water. During the Middle Ages its use seems to have been discontinued except possibly in Italy. Later it was manufactured in several European countries, but it has never attained importance in America.

The development of a cement industry in America was coincident with the construction of canal systems, the first of which, the Erie Canal, was begun in 1817. The type of cement then used is known as natural cement, which is manufactured from an argillaceous limestone calcined at a comparatively low temperature. The discovery of a process of making Portland cement by clinkering argillaceous limestone at a high temperature is usually attributed to Joseph Aspdin, an English bricklayer. His first success was attained in 1824 or 1925, but years of experimentation were consumed in finding the proper proportions of raw materials, and the optimum temperature of calcination to make a cement comparable with that produced to-day. It is noteworthy that the invention of Portland cement was contemporary in America with the first railway and the first steamship.

Portland cement was imported into the United States as early as 1868, and was first manufactured in this country by David Saylor at Allentown, Pa., about 1871. Other pioneer manufacturers began production shortly thereafter, but the difficulty of perfecting a satisfactory product and the higher cost of manufacture as compared with natural cement greatly retarded the growth of the industry. Natural cement, which was made in many plants, notably in connection with inland waterway development, held the leadership for many years. In 1897 for the first time the value of Portland cement sold exceeded that of natural cement. In 1899 the latter product attained its maximum sales value of about $4,800,000, and thereafter its use gradually declined. Portland cement on the other hand, attained a production value of nearly $6,000,000 in 1898, and from that date its growth was phenomenal. The development of the domestic Portland

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cement industry in the short period of about 50 years, from an insignificant and almost unknown activity in 1880 to its present enormous magnitude, as shown in Table 2, is probably the most dramatic event in the history of mineral production.

The facility with which concrete may be molded or shaped into any desired form in a semiliquid or plastic state, and its capability of hardening rapidly to an enduring stonelike substance, are properties of such decided advantage in construction that they were speedily capitalized. This accounts for the immediate and widespread acceptance of cement as a basic construction material and its consequent extraordinary growth, production increasing more than a hundredfold since 1880.

From a crude beginning characterized by calcination in vertical kilns and grinding with buhrstones, cement manufacture has become one of the leading industries of the nation. Annual production value now exceeds $275,000,000, and single plants produce more than 10,000 barrels of cement per day. Building industries, public works, and highway construction have been radically influenced both in design and extent by the use of Portland cement. This commodity, familiar to practically every citizen, is used in some form in or around nearly every home.

Limestone and clay or "cement rock" were the original raw materials, but others now in use include slag and limestone, oyster shells, marl, and alkali waste. Rotary kilns are universally used for calcination, and during recent years the size of kilns has been greatly increased. A recent development in the industry is toward a wider use of the wet process, with the addition of filtration equipment for removal of most of the water contained in the slurry. Noteworthy progress has been made in improving the quality of Portland cement, and in the development of a series of new quick-hardening and other special cements.

In the United States the cement industry is widely scattered. Plants are operated in at least 33 States, but the most intensive development of the industry is in the Lehigh Valley district of Pennsylvania. The area is contiguous to very extensive marketing centers, coal is readily available, and the so-called "cement rock" (an argillaceous limestone) occurs in large easily-accessible deposits and is a preferred raw material. Michigan, having abundant supplies of suitable limestone and convenient water transportation, is next in importance to Pennsylvania as a cement producer, while California and New York rank almost as high.

The cement industry views with some concern a rapidly increasing production capacity that has been attained either by erection of new plants or by remodelling or enlargement of existing mills. In 1924 the industry utilized about 85 per cent of its production capacity, but this figure has gradually declined until in 1930 the output required for its manufacture only 62.7 per cent of the available equipment.

Stone (including Slate)

Stone, unlike most of the nonmetals, has an important ancient history. Its ready availability and its enduring qualities encouraged its use in many ancient structures that stand as valuable records of the past. It probably constituted man's earliest construction material. Rock cairns were raised in prehistoric times, and slabs of stone served as tablets on which were inscribed records that have been of inestimable value to the historian and the archeologist. Flint stones were used to tip the hunter's arrow and to skin the wild animal that the arrow pierced. Stone projectiles hurled by crude implements of war were later used to batter down protecting walls of stone.

Stone was the most widely used nonmetallic mineral product in the United States 100 years ago. The earliest settlements were established along the rock-bound coasts of New England and in eastern New York, Pennsylvania, Maryland, and Virginia, where rock was abundant. The granites of New England were the first stones used extensively for building; in 1833 a number of buildings in Boston, including the court house and several churches, were built of granite quarried at Chelmsford and Quincy, Mass. Bunker Hill Monument, constructed of granite from the Quincy quarries, begun in 1825 and finished in 1843, probably marks the highest attainment in stone work of that period. Granites were also quarried in Connecticut, Maine, and other New England States, and in Pennsylvania during the early part of the nineteenth century. A quarry near Augusta, Maine, is said to have produced $50,000 worth of granite between 1836 and 1838. The great granite industries of Barre, Vt., and St. Cloud, Minn., were later developments.

Several marble quarries were in operation in Vermont and Pennsylvania as early as 1833, but the marble industry of Vermont did not become important until the period between 1850 and 1860. From a small beginning in 1838 the Tennessee marble industry has attained a leading position; and Georgia, where marble was first fabricated in a small mill in 1840, now ranks third among the States.

The well-known Triassic sandstone was quarried in considerable amount at Portland, Conn., and Hummelstown, Pa., in 1833. Sandstone quarrying in Ohio dates back more than 100 years, but the famous quarries of Amherst and Berea did not attain great importance until after the Chicago fire in 1871. Millions of tons of sandstone were shipped from these quarries for rebuilding the city.

Limestone has been used for building for a great many years, but the Indiana industry, which now far exceeds that of any other State, did not attain importance until about 1890.

Statistics of 1880 show a stone-production value in the United States of over $22,000,000, or more than 12 times the value of cement. A fluctuating though gradually expanding use is to be noted (see Table 2) for the succeeding 20 years. From 1900 to 1918 growth was more rapid, production in the latter year attaining about four times the value reached in 1880. Subsequent to the

World War value of production increased greatly until 1929, when a recession began. In value of output the cement industry overtook stone in 1913, and has thereafter far exceeded it. The rapid growth in stone production subsequent to 1918 is due principally to the great volume of crushed stone used.

Dimension stone as a whole has shown a steady and consistent growth. Conditions that have tended to retard its expansion have been more than offset by other influences. For example, cement has replaced wall stone or "cellar stone" to a very large extent, but the enormous growth of the construction industries, stimulated to some degree by the availability of cement, has created a demand for the more ornamental types of stone that has more than compensated for the decreasing requirements in the fields invaded by cement. Furthermore, evolution in architectural style that calls for rugged exteriors with variable colors and textures has greatly increased the demand for the rougher types. Stone that would some years ago be regarded as suitable only for rough foundation walls, may now be classed as of architectural grade, because it is widely used in high-class, costly residences or public buildings.

Evolution in quarry and mill equipment is noteworthy. Crude hand methods of quarrying and dressing stone have been superseded by mechanical processes requiring power drills and hoists, saws of many types, surfacing machines, power-driven polishers, and facilities for sand-blast carving.

The paving-block industry has suffered severely from competition from other types of paving materials, and it may be significant that little or no change in methods of manufacturing paving stones has taken place during the last 50 years. Stone curbing is confronted with much the same competition, but has resisted it more successfully.

Slate has been used in the Old World for many centuries. Slate tombs discovered during recent years high in the Alps were constructed about 500 B.C. A slate roof on a Saxon chapel built in England 1200 years ago is still in good condition.

Slate in the United States may shortly celebrate both its centenary and its bicentenary, for about 200 years ago, in 1734, the first slates were quarried in the Peach Bottom district on the Pennsylvania-Maryland boundary, and about 100 years ago, in 1835, systematic slate quarrying began near West Bangor, Pa. Roofing slates and monuments were the only products. From this small beginning in Pennsylvania the industry has spread to Vermont, New York, Maine, and Virginia. Production recently reaching a value of about $12,000,000 a year includes roofing, blackboards and school slates, electrical switch boards, and numerous structural forms such as tubs, sinks, stair treads, floor tile, and baseboards. Also, the simple quarry equipment consisting of crowbars, wedges, and crude windlasses used in early years has been replaced by air drills wire saws, and electric or steam hoists. It is noteworthy, however, that the splitting and trimming of roofing slate is conducted in almost the same way that it was 100 years ago. Slate as a roofing material has suffered greatly from the competition of other types of roofing, but some compensation is to be found in the great increase in use of slate as an interior structural material.

While building-stone production is an ancient industry, very little crushed stone was used until after the Civil War. The demand for crushed stone in volume began late in the nineteenth century with the introduction of water-bound macadam roads. Its use was confined almost exclusively to road building until 1898, when increasing amounts began to be used for concrete aggregate and railroad ballast. The use of crushed stone in concrete for foundations of buildings was initiated about 1900. The rapid subsequent increase in volume of production is due in large measure to the phenomenal increase in output of cement with which it was used as aggregate. In 1886 when separate statistics were first compiled, the output of crushed and broken stone was smaller in volume than that of dimension stone, while in 1930 the tonnage of crushed stone was more than 30 times as great as that of dimension stone.

The crude early methods of quarrying, using small charges of black blasting powder, followed by sledging and hand loading of the fragments into horse-drawn carts, has gradually changed. To-day thousands of tons are shot down at one time by heavy charges of dynamite in a series of churn-drill holes which often exceed 100 feet in depth. Loading is now accomplished with power shovels having dippers holding up to 10 or 15 cubic yeards, and the rock is transported in trainloads to powerful crushers. The material is further handled by the most approved types of screening and washing equipment.

Sand and Gravel

Sand and gravel were no doubt used to some extent by early peoples. Footpaths and crude roadways, if improved at all, were leveled or graded with soil, and the most available materials, whether clay, sand, or gravel, were employed. According to some authorities, sand was used extensively by the Egyptians for building temporary mounds to aid in erection of obelisks. The advantages of clean sand in plaster were known to the Romans.

Sand and gravel production as an industry was practically unknown in America 100 years ago. Each builder took the necessary sand for his mortar from some nearby bank, and he scarcely regarded it as having any monetary value. Many of the available deposits had been sorted or classified by natural processes; thus, by exercising care in selection early users of sand and gravel could satisfy their modest needs from natural deposits. The only equipment used in early times consisted of shovels and carts, with the possible addition of rough inclined screens to separate the pebbles. Building sand was the principal variety in use, and the volume of output increased as mortar and plaster were more widely employed. With the development of modern transportation systems, gravel assumed increasing importance for highway surfacing and railroad ballast.

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The first important step in technology was the classification of sand and gravel by size. It is recorded that between 1812 and 1814 when gravel roads were first built in New York some attempt was made to grade the gravel by size. Thereafter for a period of 80 years practically no progress was made in the art of size classification. It is reported that sand and gravel were first separated mechanically at Louisville, Ky., in 1894. Subsequent to that date classification rapidly became more general.

With increasing knowledge of the behavior of sand and gravel in use requirements became more exacting, and consequently important progress was made in plant design when many operators introduced screening and washing equipment whereby they could control their products and adapt them to the needs of consumers. Many new uses were found for sands, some of which demanded rigid specifications, and this movement gave added impetus to the establishment of numerous plants equipped with highly efficient machinery for classification and purification. The modern sand and gravel plant is a complex establishment equipped with power shovels, dredges, or other mechanical excavators; rotary and vibrating screens, washers, hydraulic classifiers, and dryers. In ancient times sand was thought to be a very simple commodity, and few varieties were known, possibly not more than two - fine sand and coarse sand. To-day sand is used for a multitude of purposes, and it must be purified and classified to satisfy exacting needs.

The sand and gravel industry has experienced phenomenal growth. The first available statistics are for the year 1902 when the value of the product was a little more than $1,400,000. As shown in Table 2, during the 27-year period to 1929 production increased ninety-eightfold to a value of nearly $133,000,000. Rapid gains in gross production value are to be attributed in no small measure to great extension in the use of building, paving, glass, engine, foundry, and miscellaneous sands. Gravel, like crushed stone, owes much of its enormous growth to the increasing use of concrete, because gravel is an important aggregate material. In 1929 sand and gravel held the leadership in volume of production among all the nonmetallic minerals, the output exceeding 222,000,000 tons.

As sand and gravel are low-priced commodities per ton, transportation expense is their chief marketing handicap. The high cost of conveying them long distances from large centralized plants has led to a partial reversion to the small roadside plant of many years ago. Thus the larger units are encountering increasing competition from local plants. However, the large completely equipped plants have an advantage where exacting specifications are imposed.

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Table 3.- Production value of intermediate nonmetallic group, 1880 to 1931
(Recent annual production between $10,000,000 and $50,000,000)

Year	Sulphur	Pyrite	Lime	Gypsum	Salt	Phosphate rock
1880..	$ 21,000	$ 5,000	$4,638,882	$ 400,000	$4,829,566	$1,123,823
1881..	21,000	60,000	-	350,000	4,200,000	1,980,259
1882..	21,000	72,000	-	450,000	4,320,140	1,992,462
1883..	27,000	137,500	-	420,000	4,251,042	2,270,280
1884..	12,000	175,000	-	390,000	4,197,734	2,374,784
1885..	17,875	220,500	-	405,000	4,825,345	4,145,097
1886..	75,000	220,000	-	428,625	4,736,585	1,848,939
1887..	100,000	210,000	-	425,000	4,093,846	1,836,818
1888..	-	167,658	-	550,000	4,374,203	2,039,552
1889 (Census)	7,850	202,119	8,217,015	764,118	4,195,412	2,920,276
1890..	-	273,745	-	574,523	4,752,286	3,213,795
1891..	39,600	338,880	-	628,051	4,716,121	3,651,151
1892..	80,640	305,191	-	695,492	5,654,915	3,296,127
1893..	42,000	256,552	-	696,615	4,154,668	4,136,070
1894..	20,000	363,134	8,287,821	761,719	4,739,285	3,479,547
1895..	42,000	322,845	6,588,822	797,447	4,423,084	3,606,094
1896..	87,200	320,163	6,327,900	573,344	4,040,839	2,803,372
1897..	45,590	391,541	6,372,759	755,864	4,920,020	2,673,202
1898..	32,960	593,801	6,886,549	755,280	6,212,554	3,453,460
1899..	107,500	543,249	6,983,067	1,287,080	6,867,467	5,084,076
1900..	88,100	749,991	6,797,496	1,627,203	6,944,603	5,359,248
1901..	(1)	1,257,879	8,204,054	1,506,641	6,617,449	5,316,403
1902..	(1)	947,089	9,335,618	2,089,341	5,668,636	4,693,444
1903..	(1)	1,109,818	9,255,862	3,792,943	5,286,988	5,319,294
1904..	2,663,760	814,808	9,951,456	2,784,325	6,021,222	6,580,875
1905..	3,706,560	938,492	10,941,680	3,029,227	6,095,922	6,763,403
1906..	5,096,678	931,305	12,480,653	3,837,975	6,658,350	8,579,437
1907..	5,142,850	794,949	12,656,705	4,942,264	7,608,323	10,653,558
1908..	6,368,215	857,113	11,091,186	4,075,824	7,553,632	11,399,124
1909..	4,432,066	1,028,157	13,846,072	5,906,738	8,343,831	10,796,456
1910..	4,605,112	977,978	14,088,039	6,523,029	7,900,344	10,917,000
1911..	4,787,049	1,164,871	13,689,054	6,462,035	8,345,692	11,900,693
1912..	5,256,422	1,334,259	13,970,114	6,563,908	9,402,772	11,675,774
1913..	5,479,849	1,286,084	14,648,362	6,774,822	10,123,139	11,796,231
1914..	5,954,236	1,233,346	13,268,938	6,895,989	10,197,417	9,608,041
1915..	4,959,000	1,674,933	14,424,036	6,596,893	11,747,686	5,413,449
1916..	12,246,000	1,965,702	18,509,305	7,959,032	13,645,947	5,896,993
1917..	23,987,000	2,485,435	23,807,877	11,116,452	19,940,442	7,771,084
1918..	27,868,000	2,644,515	26,808,909	11,470,854	26,940,361	8,214,463
1919..	10,252,000	2,558,172	27,643,000	15,727,907	27,074,694	11,591,268
1920..	30,000,000	1,596,961	37,543,840	24,533,065	29,894,075	25,079,572
1921..	17,000,000	711,432	24,895,370	23,700,290	24,557,966	12,270,070
1922..	22,000,000	671,241	33,255,039	29,361,151	27,464,838	10,482,846
1923..	26,000,000	661,000	39,993,652	34,888,155	27,795,941	11,576,049
1924..	25,000,000	645,262	39,596,423	42,724,507	25,747,048	10,253,083
1925..	29,000,000	650,448	42,609,141	47,577,240	26,162,361	11,545,678
1926..	37,300,000	616,668	41,566,452	46,721,219	25,055,012	10,893,800
1927..	38,300,000	804,006	38,638,413	42,174,454	24,817,962	11,253,352
1928..	37,500,000	605,459	36,449,635	32,036,163	26,772,568	12,443,179
1929..	43,800,000	1,250,141	33,478,848	31,292,969	27,334,695	13,153,259
1930..	35,800,000	1,028,680	25,616,486	27,051,484	25,009,480	13,996,830
1931..	24,800,000	974,820	18,506,000	20,801,357	21,541,012	9,288,485

1/ Sulphur figures included with pyrites, 1901-1903.

Sulphur and Pyrite

As indicated in Table 3, the mining of native sulphur was a small industry in the United States prior to 1904, and pyrite (iron sulphide), both domestic and imported, was the chief source of sulphur up to that time. The invention of the Frasch process transformed the industry. The basic principle of this process involves injection into the deposit of a large volume of superheated water which melts the sulphur and permits its removal in liquid form. Successful application of this method to the enormous deposits of sulphur-impregnated limestones of Texas and Louisiana resulted in rapid growth of the industry. The principal use of sulphur is for manufacture of sulphuric acid. Prior to the World War, pyrite, most of which was imported from Spain, was the chief source of sulphur for this and other uses. Native sulphur from the Gulf Coast region, however, was gradually gaining a stronger foothold in the sulphuri acid industry, and with paralysis of shipping due to war conditions and consequent reduction in imports of pyrite from Spain in 1917 the use of sulphur for acid manufacture was very greatly increased. At the close of the war many acid plants continued to use native sulphur. Sulphuric acid is essential to a multitude of industrial uses, and, with noteworthy expansion of the chemical industries that characterized the period subsequent to 1916, the native sulphur industry experienced remarkable growth. As indicated in the table of value by years, production increased enormously at two periods - in 1904 under the influence of the Frasch process, and in 1916 when substitution of sulphur for pyrite became general, and war conditions gave increasing impetus to chemical industries requiring sulphur.

Pyrite production, as shown in Table 3, maintained a uniform level from 1901 to 1914, when, under war stimulus, there was a considerable increase. Subsequent to 1920 production declined sharply, partly on account of increasing substitution of native sulphur, and partly because of continued substantial imports of pyrite. The increase from 1928 to 1930 is more apparent than real, because for those years by-product pyrite and pyrrhotite from copper and zinc smelters was included with the production from pyrite mines. For some uses pyrite is preferred to native sulphur.

Lime

The conversion of limestone into lime under the influence of heat was evidently known to the ancients. Early discovery of the process was to be expected, for limestones were no doubt used in remote ages to support cooking utensils or to confine camp fires. Lime mortar was used in Egypt and elsewhere in early stages of human progress. Lime plaster was employed primarily as a coating rather than as a binding material for masonry. It was used by the Egyptians in the chambers of pyramids and in temples as early as 2,000 B.C. The ancient Greeks applied lime stucco on their temples. The manufacture of lime made possible the manufacture of puzzolan cement, mentioned previously. During the Middle Ages lime mortar was widely used in masonry construction of cathedrals, fortresses, and other buildings. Occasionally when an impure limestone was calcined, a hydraulic lime was made, but such occurrences were accidental, and their significance was not realized. Common lime mortar and

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hydraulic gypsum mortar mentioned later were practically the only masonry binders used prior to the invention of natural cement. The gradual replacement of lime by natural cement for masonry use in America was noted as early as 1886, although cement had made no perceptible inroads in the industry at that time.

The earliest dependable United States statistics are census figures for the year 1880, which show a value of lime production of $4,638,882. The census figure for 1889 was nearly double that amount, but the industry made little additional progress for a number of years, in fact as may be seen in Table 3, a recession in production value occurred from 1895 to 1900. Beginning in 1901 a gradual expansion may be noted but not until the World War period did production increase rapidly. A maximum output valued at more than $42,000,000 was attained in 1925, but subsequently the industry suffered a decline which became precipitous after 1929. As lime is used in many chemical industries, the notable expansion in manufacture of chemicals during and subsequent to the World War accounted in some degree for the maintenance of lime production at a high level. Postwar building activity was a contributory cause, though lime used in the building trades has suffered from the competition of both cement and gypsum.

Statistics of lime sales were separated by uses for the first time in 1906, in which year 86 per cent by value was used in the building trades, 8 per cent in the chemical and manufacturing industries, and 6 per cent for agriculture. The proportional amount used for building decreased rapidly until 1917 when only 42 per cent was so used, but postwar building activity increased this percentage to about 56 for the years 1921 to 1927. Thereafter it again declined, and in 1930 fell to 39 per cent, the lowest point on record. The percentage of lime used in the chemical and manufacturing industries, on the other hand, increased rapidly from only 8 per cent in 1906 to 48 per cent in 1917. It has shown some fluctuation, but has maintained a high level during subsequent years, reaching a maximum of 51 per cent in 1930.

The most noteworthy trend in the lime industry, therefore, is toward relatively decreasing use in the building trades, where severe competition is encountered, and a relative increase in the chemical industries, where lime is essential as the cheapest known base and where it meets with little or no competition.

The value of lime used in agriculture has varied from 5 to 15 per cent of the total. There are no notable trends except during the war period, when the proportional amount attained a maximum. This condition was no doubt due to the stimulation of a world demand for food supplies.

Gypsum

Both ordinary massive gypsum and the translucent variety known as alabaster were used by the ancients for building and for carving into ornaments. Gypsum plaster was used like lime plaster for wall coatings in ancient pyramids and temples. Hydraulic gypsum mortar, that is, a mortar made of gypsum calcined at a high temperature, was used in construction of the Great Pyramid of Cheops built more than 4,000 year ago. Plaster of Paris, which results from calcination of gypsum at moderate temperature, was also known to the ancient Egyptians and Greeks, but was not used extensively. The Romans were familiar with the virtues of gypsum as a fertilizer.

In America, the use of gypsum as land plaster was known to the settlers during their westward migration as early as 1800. It was first used for this purpose in Virginia about 1835, in Michigan about 1842, and during subsequent years was employed in increasing amounts in other States. Later the use of gypsum for fertilizer declined considerably.

The earliest domestic manufacture of plaster of Paris was about 1835. The raw rock was ground in a corn mill, and calcined in a cauldron kettle. Improved methods of grinding and calcining were gradually developed, and plants for manufacture of gypsum plaster were established in New York, Michigan, Ohio, Iowa, Colorado, and other States. The early growth of plaster of Paris manufacture was coincident with the decline in the use of gypsum in agriculture.

The first dependable statistics of production date from the year 1880 when the output for the United States was valued at $400,000. The figures given in Table 3 represent the combined value of raw and calcined gypsum sales by companies that both mine and calcine the product. It may be observed that there was little or no growth from 1880 to 1887, and a gradual expansion with considerable fluctuation until 1898. The slow growth in this period is to be attributed in part to decreasing use as land plaster. In 1880 about 50 per cent of the total production was sold for land plaster, in 1904 the proportion had decreased to 10 per cent, in 1913 to about 2 per cent, and in 1930 to less than 1 per cent. Lack of a sustained market for raw gypsum in agriculture was more than compensated for in later years, however, by increasing use as a cement retarder. In 1908 nearly 11 per cent of all gypsum mined was sold to cement plants, in 1913 it reached nearly 16 per cent, in 1920 about 17 per cent, and in 1930, 27 per cent.

Subsequent to 1898 growth was much more rapid, the increase being due chiefly to the rapidly widening use of calcined gypsum. It was used in the construction industries primarily for wall plaster, but many new types of building materials were subsequently developed. The great expansion in volume of production that characterized the years since 1920 was due chiefly to the enormous increase in use in many types of construction of such products as plaster board, wall board, lath, precast partition blocks, tile, and roofing slabs.

An important recent trend in the industry is toward the establishment of calcining and gypsum product manufacturing plants near the large marketing centers. Raw gypsum movement from mine to manufacturing plant is facilitated by water transportation along both Atlantic and Pacific seaboards and on the Great Lakes. Annual importation of about 1,000,000 tons of raw gypsum from eastern Canada to supply manufacturing plants in eastern cities of the United States is noteworthy.

Salt

Common salt (sodium chloride) is now regarded as an essential food constituent, and was so used in the earliest periods of human history. Some inland races, however, lived without a knowledge of salt; it was indeed less essential when food was used without boiling. The use of salt became more general with the advance of civilization from nomadic to agricultural life. Through its employment as a food, as a preservative, and in sacrificial rites it gradually assumed importance as an article of commerce. Some well-known roads and caravan trails were established to promote trade in salt -- for example, the Via Salaria of Italy. The imposition of salt taxes and maintenance of Government monopolies are further evidences of its importance in ancient as well as modern commerce.

Salt production was one of the first American industries. In early years of the nineteenth century Hudson's Bay Co. of Canada obtained local supplies from brine springs in the Mackenzie River Basin. The industry began in Ontario in 1866, but no rock salt was mined in that province prior to 1918.

In the United States the Indians obtained salt from saline springs near Syracuse, N. Y., as early as 1653. It is recorded that in 1670 and during later years the Delaware Indians sold salt to settlers in northern New York and in Canada. White people began its manufacture from brine near Syracuse about 1788. Rock salt was first discovered in western Ontario County, N.Y., in 1865, and between 1888 and 1896 numerous wells were drilled for the extensive salt and chemical industry near Syracuse. Deposits in Michigan, Ohio, and other States later attained very great importance. Salt is very widely distributed in the United States, and the resources are inexhaustible. Single beds are of sufficient extent and thickness to supply the needs of the entire world for centuries.

Production figures for the Onondaga district of New York are recorded as far back as 1797. Earliest dependable statistics for the entire country show a production value of about $4,800,000 in 1880. From this time until 1892 the quantity used increased greatly, but the price constantly declined, on which account the values from year to year given in Table 3 show very little increase. The apparent decline in value for a few years subsequent to 1893 was due to elimination from the totals of the value of the barrels or other packages, a figure which was included in prior years. Processes of purification of salt were greatly improved in 1902 and in consequence imports of the more refined grades, chiefly from England, were substantially reduced. For the years 1894 to 1897 the import duty was removed, creating a keen competition with foreign supplies.

Growth of the salt industry was slow until 1897. Table and dairy uses were the principal outlets up to that time, so that growth depended largely on population. However, the per capita consumption showed some increase due to enlarged demands for meat packing and in gold and silver metallurgy. The substantial increase in value of production subsequent to 1897 is to be attributed in some measure to growth in the industries utilizing brine for manufacture of soda ash, bleaching powder, and other chemicals having a sodium base. The higher the refinements of civilization became, the more salt was used per capita, because to its uses as a food and a preservative were added its many and increasing applications in chemistry, metallurgy, and ceramics. Thus the per capita consumption in 1890 was about 39 pounds per year; in 1900 it was 77 pounds; in 1910, 92 pounds; in 1920, 124 pounds; and in 1930 about 134 pounds. The relatively large requirement per person as compared with the small amount used for culinary purposes indicates how extensively salt is used in industry.

War demands during the years 1915 to 1919 led to a pronounced increase in production, particularly for chemical requirements. This was the period of most rapid growth in the industry, but the notable increase in value was due to a high price level as well as to increase in demand. Following the depression of 1921 the industry has maintained a high production value, which is due in part to sustained demands in the chemical industries, in refrigeration, and in metallurgy - and in part to the maintenance of relatively high price levels as compared with pre-war figures.

As salt is widely distributed, readily available, and enjoys a comparatively steady market, the industry is characterized throughout its history by keen competition and a narrow margin of profit.

Phosphate Rock

Phosphate rock utilization for land fertilizer began on the east coast of England about 1842 or 1843. In America the first shipments were made from Charleston,,S.C., in 1867. South Carolina was the only producing State for many years. As the chief markets were in Europe, an export trade was developed shortly after production began, and exports have continued to be an important feature of the industry.

The most noteworthy dates in the history of American phosphate rock mining are 1888 when the Florida deposits were first utilized, 1894 when the "blue rock" of Tennessee was found, and 1896 when production began in the "brown rock" fields of Tennessee. As the phosphates of Florida and Tennessee are of higher grade than those of South Carolina, the industry in the latter State gradually languished until it disappeared. A small tonnage was obtained in Kentucky, Arkansas, Pennsylvania, Alabama, and South Carolina between 1896 and 1926. Since 1927 a small production is reported from Idaho, Montana, and Wyoming, but Florida and Tennessee dominate the industry.

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Sales of phosphate rock in 1880 were valued at a little more than $1,100,000. Growth of the industry as shown in Table 3 was fairly steady until 1905, and thereafter sales were at a much higher level, attaining a maximum for the pre-war period of nearly $12,000,000 in 1911. War conditions cut exports so greatly that the industry was reduced in 1915 and 1916 to about one-half its former magnitude, but recovery began in 1917. Production suddenly jumped to record proportions in 1920, the sales value exceeding $25,000,000, but dropped back to normal in 1921. A steady increase in sales value was recorded from 1926 to 1930.

Tennessee production has been fairly uniform at about one-half a million tons since 1899, while Florida has shown the most rapid growth and the greatest fluctuations. Florida production reached a maximum of more than 3,300,000 tons in 1920 when production for the entire country attained a high level exceeding 4,100,000 tons.

Prosperity in the phosphate rock industry depends in large measure on the extent of export trade, which absorbs from 25 to 40 per cent of total production. Exports increased at a uniform rate from 1898 to 1913, when more than 1,300,000 tons were sold in foreign lands, but war conditions caused a decline to about one-tenth the pre-war volume. A sharp postwar recovery almost to prewar levels was followed by a decline of about 30 per cent in 1921 and 1922. Thereafter exports increased with some fluctuations until they almost regained the peak volume of 1913.

The United States dominated foreign markets for many years, but competition from extensive deposits in northern Africa has recently become an important factor in world trade. While African competition is felt most keenly in European markets, United States exports to Europe as a whole have been maintained remarkably well. Japan is becoming an increasingly important outlet for American phosphate rock.

Table 4.- Production value of certain minor nonmetallic minerals, 1880 to 1931
(Recent annual production less than $10,000,000)

Year	Abrasives	Asbestos	Barite (crude)	Diatomite & tripoli	Feldspar (crude)	Fluorspar
1880	$ 737,280	$ 4,312	$ 80,000	$ 45,660	$ 60,000	$ 16,000
1881	738,580	7,000	80,000	10,000	70,000	16,000
1882	990,000	36,000	80,000	8,000	70,000	20,000
1883	860,000	30,000	108,000	5,000	71,112	20,000
1884	840,000	30,000	100,000	5,000	55,112	20,000
1885	723,000	9,000	75,000	5,000	68,000	22,500
1886	521,190	6,000	50,000	6,000	74,500	22,000
1887	448,400	4,500	75,000	15,000	56,100	20,000
1888	472,420	3,000	110,000	7,500	50,000	30,00
1889	613,289	1,800	106,313	23,372	39,370	45,83
1890	633,024	4,560	86,505	50,240	45,200	55,32
1891	732,930	3,960	118,363	21,988	50,000	78,33
1892	623,691	6,416	130,025	43,655	75,000	89,000
1893	632,924	2,500	88,506	22,582	68,307	84,00
1894	560,570	4,463	86,983	11,718	98,900	47,500
1895	585,497	13,525	68,321	20,514	30,000	24,000
1896	658,614	6,100	46,513	26,792	35,200	52,000
1897	731,387	6,450	58,295	22,835	43,100	37,15
1898	1,058,103	10,300	108,339	16,691	32,395	63,050
1899	1,160,909	11,740	139,528	37,032	211,545	96,650
1900	1,143,161	16,310	188,089	24,207	100,813	94,500
1901	1,100,322	13,498	157,844	52,950	(1) 75,686	113,803
1902	1,189,176	16,200	203,154	53,244	114,927	271,832
1903	1,340,122	16,760	152,150	76,273	160,807	213,617
1904	1,287,837	25,740	174,958	44,164	155,290	234,755
1905	1,275,225	42,975	148,803	64,637	147,628	362,488
1906	1,279,614	28,565	160,367	72,108	241,079	244,025
1907	1,449.749	11,899	291,777	104,406	300,729	287,342
1908	897,451	19,624	120,442	97,442	246,066	225,998
1909	1,207,402	62,603	209,737	122,348	210,688	291,747
1910	1,276,799	68,357	121,746	130,006	269,626	430,196
1911	1,378,301	119,935	122,792	147,462	291,285	611,447
1912	1,476,547	87,959	153,313	125,446	291,171	769,163
1913	1,362,757	11,000	156,275	285,821	395,842	736,28
1914	1,107,715	18,965	155,647	252,327	415,325	570,041
1915	1,051,034	76,952	381,032	167,474	311,097	764,475
1916	1,380,286	448,214	1,011,232	241,553	404,689	922,654
1917	2,015,609	506,056	1,171,184	123,784	474,767	2,287,722
1918	2,639,531	124,687	1,044,905	224,801	429,989	5,465,481
1919	2,174,401	243,700	1,555,793	444,461	347,992	3,525,574
1920	2,650,442	678,231	2,142,464	1,649,370	851,123	4,718,647
1921	1,860,985	336,968	531,958	895,629	617,652	724,094
1922	2,029,277	10,120	1,123,950	703,397	844,568	2,531,168
1923	2,927,235	9,626	1,664,156	1,082,163	1,057,595	2,505,819
1924	2,877,351	42,526	1,540,744	1,083,326	1,509,339	2,451,13
1925	2,948,580	51,700	1,703,097	1,357,167	1,315,654	2,052,342
1926	2,963,696	134,731	1,773,293	1,605,173	1,607,101	2,341,277
1927	2,671,450	336,882	1,670,878	(2) 447,068	1,424,755	2,034,728
1928	2,623,899	351,178	1,754,924	(2) 555,576	1,418,975	2,656,55
1929	2,350,354	351,004	1,850,706	(2) 545,658	1,276,640	2,791,12
1930	1,632,497	289,284	1,538,171	(2) 507,505	1,066,636	1,746,64
1931	992,799	119,967	994,655	(2) 310,131	861,059	931,27

1/ From 1901 crude and ground feldspar at value of crude. Before 1901 values were reported on a less certain basis and are not strictly comparable.

2/ Figures for tripoli only.

Abrasives

Several minerals and rocks are utilized for their abrasive qualities in various processes of grinding, pulverizing, or polishing. The chief members of this group are emery, garnet, quartzose rocks used for tube-mill linings, millstones, or grinding pebbles; sandstones employed as grindstones, pulpstones, oilstones, scythestones, and similar products; also diatomite, tripoli, and certain volcanic materials such as pumice and pumicite. The most important of them in 1880 were grindstones, pulpstones, millstones, and emery, the total value of which reached nearly three-quarters of a million dollars. As noted in following paragraphs many changes in utilization have occurred since that time. For quite a number of years the uses of diatomite and tripoli have been greatly enlarged, and so small a proportion of these products has been used as abrasives that their values have been eliminated from the abrasive totals which appear in Table 4. Sand is an important abrasive with a recent production value approximately equal to that of all the other natural abrasives combined, but it is not included in Table 4, as the values of annual production have already been included in the totals for sand and gravel in Table 2.

Emery and corundum were important abrasives subsequent to 1881 when production was valued at $80,000 per year. A maximum production value of $275,000 was reached in 1898, but this high figure is evidently due in part to an overestimate of value per ton. A noteworthy decline began in 1903 when the output was valued at only $64,000. The stagnation which marked the industry from that year until 1916 was due to three causes: (1) Continued large importations of emery from Naxos, Greece, (2) importation of a considerable tonnage of corundum from Canada, and (3) a rapidly increasing use of artificial abrasives. Silicon carbide (e.g., "Carborundum") is the best known member of this group. Production of this electric furnace product which amounted to only 100,000 pounds in 1894 had increased to 1,741,000 pounds in 1899, to 2,400,000 pounds in 1900 and to 7,000,000 pounds in 1904. During the World War period imports of emery were greatly restricted, and domestic production attained a value of about $241,000 in 1917. The postwar decline was rapid, and, although competition from Canadian corundum has disappeared the other two influences that were in effect prior to the war have continued in force. Corundum production has ceased, and, since 1924, domestic production of emery has become almost insignificant. A minimum production value of only about $3,600 was reached in 1926.

Garnet, first reported in 1894, has grown to an industry producing abrasive grains valued at one-half to nearly three-quarters of a million dollars per year. About 90 per cent of the output is used for manufacture of coated abrasive papers, a use for which it has withstood reasonably well the competition of artificial abrasives. Annual production has ranged from 3,000 to 8,000 tons per year. Values varied from $100,000 to $200,000 per year until 1919 when a great increase took place, culminating in a maximum value of more than $700,000 in 1925. Thereafter the value has steadily declined to less than half that amount. Abrasive paper manufacture is the mainstay of the industry, and as garnet makes little headway for other abrasive uses, no increase in demand is anticipated.

The grindstone and pulpstone industry has shown little growth. The value of such products in 1880 was about $500,000. From 1886 to 1898 it ranged from $220,000 to about $400,000 per year, and thereafter there was a gradual increase to a maximum of more than $1,870,000 in 1926. From that year production value has steadily decreased to about $770,000 in 1930. The condition shown by these figures would not, for some industries, be regarded as representing an abnormally slow development, but in view of the enormous growth in grinding processes since 1880, and the great expansion in paper pulp manufacture, it is evident that artificial abrasives have displaced natural stones to a very great extent. Future enlargement of the natural grindstone and pulpstone industry is highly improbable; a further decline is, in fact, to be expected.

Buhrstones and millstones were important types of grinding equipment 50 years ago. From 1880 to 1887 the annual value of sales varied from $100,000 to $200,000. Decline began with invention of the roller mill for grinding grain and from the late eighties production value has ranged from only $20,000 to $50,000 a year. The decline is due in part to the gradual disappearance of the old master craftsmen who were skilled in dressing the stones, and in part to the development of more efficient processes of grinding grain, paint, and minerals.

Annual production of grinding pebbles and tube-mill linings varies from 3,000 to 6,000 tons valued at $30,000 to $90,000. This small industry has some promise of growth. Imported French and Danish flints supply most pebble-mill needs.

Pumice and pumicite are used principally as abrasives in the manufacture of cleansing powders and scouring soaps. Production was first recorded in 1902 with a value of output for that year of $2,750. Expansion to a value of nearly $17,000 was reported in 1906, and thereafter, with a few exceptional fluctuations, growth has been uniform and rapid, attaining a maximum of $353,000 in 1929. Pumice suffers little from competition with artificial abrasives, and therefore its production has shown a growth more rapid and consistent than that of most natural abrasives.

Silica sand has long been used for cutting and grinding, notably in the stone industries, where it is employed in the sawing process and also in rubbing stone surfaces to size and to the desired smoothness. It is also used for sandblasting. As previously noted the annual values of abrasive sand are not included in the abrasive column of Table 4 but are included in the sand and gravel totals as given in Table 2. Statistics dating from 1911, however, show sales of 600,000 to over 1,000,000 tons per year until 1922, and thereafter 1,400,000 to 1,860,000 tons per year until 1930 when sales fell to about 1,100,000 tons. Values ranged from 50 cents to a little over $1 a ton prior to 1918, and subsequent to that date they varied from $1.30 to $1.80 per ton.

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It may be observed, therefore, that sand has been used in substantial amounts for many years, and that no noteworthy increase in its use is recorded. Some of the industries using abrasive sand have grown greatly during the past 20 years, but their abrasive needs, as in several other instances recorded previously, have been supplied to a large extent by artificial products. However, silica sand is a satisfactory abrasive for many applications, and its low price will justify its continued use. Therefore a well-sustained production with moderate expansion is to be expected.

As shown in Table 4, natural abrasives as a group, exclusive of abrasive sand, attained their maximum production value of $2,963,696 in 1926, and thereafter the value has steadily declined. On the other hand, artificial abrasives, notably those of the silicon carbide and aluminum oxide types, have rapidly increased in use, particularly under the stimulus of World War conditions. The maximum value of more than $10,800,000 attained in 1929 indicates how extensively electrical furnace products have invaded the field formerly occupied by natural rocks and minerals. Probably no nonmetallic minerals show less promise of future growth and development in use than the group of natural abrasives.

Asbestos

The use of asbestos dates far back in ancient history. Pliny referred to it under the name amiantus, stating that is was used for winding sheets, table cloths, and other fabrics. Asbestos paper was known nearly 200 years ago. Pontoppidian, Bishop of Bergen, in his Natural History of Norway, published in 1750, refers to paper made from asbestos found in the parish of Waldens. He stated that the paper did not burn when thrown in the fire, but the writing on it totally disappeared. This indicates that the primary object was to obtain an incombustible writing paper. Many experiments were conducted with mixtures of asbestos and combustible material. Some papers thus made would burn but would leave a white residue which retained its shape and preserved the written characters. All efforts directed toward development of a suitable writing paper were evidently unsuccessful. Other early uses of asbestos paper were for ornamental wall paper and carpet linings.

Asbestos paper is now a very important product, but its present uses as a fireproofing and heat-insulating material were not contemplated by the pioneer investigators. It was first made in America at Waltham, Mass., in 1876. Its value for heat insulation was speedily recognized, and the industry grew rapidly. At present a number of large factories make in all more asbestos paper in a day than was made in an entire year 25 years ago.

Italy was the cradle of the asbestos industry. The deposits of the Alps were exploited between 1860 and 1880 for rope packings and heat-insulating board, but much difficulty was encountered in devising suitable machinery for its fabrication into spun products. Canadian asbestos discovered near Thetford Mines in the Province of Quebec about 1860 was found to be much easier to fabricate than the Italian product.

The spinning and weaving of asbestos for textile manufacture began in America more than 50 years ago. The early products were chiefly fireproof garments such as coats, shoes, gloves, and helmets. Disastrous theatre fires led to the use of asbestos curtains, but it was not until the advent of the automobile that asbestos fabrics were produced in quantity. Asbestos brake linings for automobiles were first made in England in 1896, but 1906 seems to be the earliest date that asbestos was used for brake bands in the United States. Asbestos mill board, wall board, corrugated sheeting, and other building materials are all products of the last 15 or 20 years.

The United States is the leading country in the world for manufacture of asbestos products. The extent and growth of asbestos product industries are shown in Table 5, compiled from Bureau of the Census figures. (The high figure of 1919 was due to war stimulation.)

Table 5.- Asbestos products in the United States

Year	Number of establishments	Value of products
1914	181	$17,026,175
1919	215	64,502,336
1921	197	42,142,897
1923	198	69,811,681
1925	221	80,144,936
1927	221	87,200,889
1929	238	101,597,171

Although the asbestos manufacturing industries of the United States are of great importance, domestic sources of raw material have never provided more than a small fraction of the requirements. In 1880 a production of 150 tons was divided between Georgia, South Carolina, Maryland, and New York. In 1882 production had reached 1,200 tons but declined greatly in 1885 and for several years following because of increased importations from Canada. From 1890 to 1894 a small production was confined to the Western States, and from 1895 to 1901 fiber was obtained at widely scattered points both in the East and West. Practically the entire production prior to 1905 was amphibole, which was used for asbestos cements and paints.

The chrysotile deposits near Eden, Vt., received first attention in 1900, and those of Arizona in 1903, but no production of chrysotile worthy of mention was recorded prior to 1905. Vermont attained some prominence in 1908 and 1909, and became the chief producer in 1911 and 1912; thereafter production almost ceased but again attained some importance in 1929 and 1930.

As shown in Table 4, production has fluctuated greatly and has never been large. The maximum quantity for any one year, 7,604 tons produced in 1911, consisted chiefly of the relatively low-priced short-fiber chrysotile of Vermont. A maximum value of over $678,000 was attained in 1920 when high-grade spinning fiber from Arizona was sold at abnormally high prices.

Several factors have contributed to retardation of the domestic industry. First, no available supplies of high-grade spinning fiber have been developed except in Arizona, and the Arizona deposits are seriously handicapped by their remoteness from principal markets. Second, while deposits of short-fiber chrysotile and nonspinning amphibole are available in many localities, they must compete with the abundant supplies of short fiber shipped from the extensive mines in Quebec, Canada. The enormous asbestos product manufacturing industries of the United States have no difficulty in obtaining, duty free, ample supplies of all types of fiber from foreign sources.

Canada was the first active competitor. From an almost insignificant importation valued at $18 obtained from that country in 1873, imports had increased to $69,000 in 1885 and to $353,000 in 1891. They passed the $1,000,000 point in 1906, attained a value of $4,000,000 in 1917, and reached a maximum of over $11,000,000 in 1929. Russia was a source of supply of some importance prior to the World War and has again become an important source since 1925.

The Union of South Africa recorded a small production beginning about 1900, which increased to 1,200 tons in 1908. Rhodesia joined the producing countries in 1908 with an output of 55 tons. African competition was first felt about 1916 when more than 1,000 tons of spinning fiber were imported, either directly from ports of the Union of South Africa or through England. This amount was nearly doubled the following year, and was supplemented by an importation of nearly 500 tons from Rhodesia. Growth of the Rhodesian industry was phenomenal, and fiber from this source has dominated the trans-Atlantic trade. Imports originating in Africa have ranged since 1916 from 2,500 to 6,000 tons per year with a maximum of 8,400 tons in 1929. While this tonnage is relatively small compared with the 200,000 to 250,000 tons obtained each year from Canada, practically all of the African fiber is of the higher-priced spinning grades.

It may be said, therefore, that Canada dominated the American asbestos market from 1880 until 1915. From that year until 1926 Canada and Africa have been keen competitors for United States trade, and from 1926 a three-cornered contest for that market has been waged by Canada, Africa, and Russia. Canada has always dominated the short-fiber market. It is not surprising, therefore, that the domestic asbestos-mining industry has not prospered.

Barite

Barite was first mined in Virginia about 1845 and in Missouri about 1860. Production on a commercial scale began in Kentucky about 1903, in Alabama about 1906, and in Georgia and Nevada about 1907.

This heavy and chemically inert material found early use as an adulterant. Therefore it became unpopular, and laws were passed in some countries forbidding its use in foods. It was first used as a paint pigment in America about 1850. In this field of application it was for many years regarded simply as an adulterant of white lead. Throughout its early history, therefore, the mineral was generally frowned upon, and its progress was retarded by the handicap of unpopularity.

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During later years scientific investigation of the properties of barite proved it to be a legitimate paint ingredient having advantageous qualities for certain important uses. Thereafter the ability of the mineral to face competition on its inherent merits, rather than as a substitute to be used more or less secretly in the place of a more expensive component, led to much wider use. Its principal field of application has always been in the paint industry.

Production in 1880 was valued at $80,000. During succeeding years the tonnage increased gradually, but as the price steadily declined there was little growth in value of output prior to 1898. Prices recovered in 1898 and were moderately well sustained during succeeding years. Volume of production also increased considerably.

Barite was used primarily as a pigment in mixed paints, and as a base in the manufacture of lake pigments. About 1909 lithopone, a mixture of zinc sulphide and barium sulphate, attained some prominence as a paint material, and it has become of very great importance, dominating the entire field of utilization.

Germany is the chief foreign source of barite, and imports from that country have had a decided influence on the domestic industry. For several years prior to the World War imports ranged from 20,000 to 35,000 tons a year, or from 25 to 80 per cent of domestic production. With the beginning of hostilities in 1914 imports dropped rapidly, and they practically ceased in 1916 and 1917. At the same time demands for the mineral increased notably; United States production doubled in quantity from 1914 to 1915, and it again more than doubled from 1915 to 1916. As may be noted from Table 4, the value increased even more rapidly because of mounting prices. Production value attained its maximum of over $2,000,000 in 1920, even though imports were resumed at almost pre-war volume.

The noteworthy growth of the industry from 1914 was due to a much wider use of lithopone in paints and to a great expansion in manufacture of barium chemicals. Prior to the World War the principal requirements of such chemicals were supplied by imports, but lack of sufficient quantities from foreign sources between 1914 and 1920 led to the development of important barium chemical industries in the United States. These industries have been maintained and have increased in importance even though faced with a great volume of competing products, the importation of which was resumed in 1920.

Sixty-four to 67 per cent of the barite consumed in the United States during recent years has been used for lithopone manufacture. Ground barite, used as a white pigment, filler, and inert base, has been an important product from early days and has recently consumed from 18 to 25 per cent of the total barite produced. Barium chemical manufacture, nurtured by war necessities, has advanced from a small industry in 1915 to one of considerable magnitude. In 1930 for the first time the amount of barite used for manufacture of chemicals (nearly 24 per cent of the total) exceeded the amount used for manufacture of ground products.

Missouri and Georgia have been the leading producing States for many years with Tennessee standing third. California has attained some importance since 1926.

Foreign supplies have had a marked influence on regional development of the domestic industry. Before the World War the eastern deposits in Georgia and Tennessee could not compete with the low-priced German barite, and production in these States was small. When foreign supplies were cut off in 1916 the eastern industry flourished and dominated production for several years. From 1926 large imports again depressed eastern production, and Missouri became the leading State.

Diatomite and Tripoli

Diatomite (diatomaceous earth, or infusorial earth) is a fine-grained, more or less loosely consolidated, light-weight material consisting principally of hydrous silica. The minute grains are remains of aquatic plants known as diatoms. Tripoli consists of fine-grained siliceous material which has resulted from the leaching of siliceous limestones or calcareous cherts. Under a microscope the organic structure of diatomite is plainly seen, while tripoli shows no organic structure.

Diatomite and tripoli have been considered together in statistical compilations, partly because for many years the terms were synonymous, materials of both kinds being considered as a single product. It was not until 1908 that the terms were defined as in the preceding paragraph, although the inherent differences in the materials had been recognized long before that time. Another reason for considering them together is the similarity in their uses.

In statistical reports diatomite and tripoli have been grouped with abrasives because their primary uses were for the manufacture of polishing materials, abrasive soaps, and scouring powders. Only a small part of present production of these minerals is used for abrasive manufacture, but they are still included in that group simply because their other uses as fillers, filter stones, foundry facings, heat insulation, concrete admisture and fireproofing compounds are so diverse that no logical subject heading can be employed.

As may be noted from Table 4, value of production fluctuated greatly. This is due in part to changes from year to year in the extent to which the mine products are manufactured or prepared before they are marketed. Fluctuations were also occasioned by the mining in certain years of enough material to satisfy sales requirements of several ensuing years.

As a substantial part of the diatomite and tripoli produced enters trade first in ground form or otherwise prepared, the values given are, for most years, considerably higher than the values of the crude minerals.

For many years the figures for tripoli and diatomite were not separated. From general statements and occasional figures it appears that diatomite was the chief product until about 1892. Thereafter tripoli was foremost in volume of output until 1919, when diatomite again took the lead. Separate figures available since 1913 are shown in Table 6.

Table 6.- Diatomite and tripoli sold in the United States, 1913 to 1930, in short tons

Year	Diatomite	Tripoli	Total
1913	6,586	20,797	27,383
1914	11,012	17,218	28,230
1915	4,593	30,711	35,304
1916	2,721	43,257	45,978
1917	3,033	26,069	29,102
1918	2,965	19,982	22,947
1919	42,642	24,292	66,934
1920	61,922	40,233	102,155
1921	55,134	12,340	67,474
1922	44,761	30,205	74,966
1923	65,833	27,082	92,915
1924	63,163	28,476	91,639
1925	73,030	29,388	102,418
1926	87,126	31,369	118,495
1927	(1)	26,099	-
1928	(1)	34,043	-
1929	(1)	38,011	-
1930	(1)	32,439	-

1/ Figures not recorded.

It may be observed by comparing figures in Table 6 with those given in Table 4 that while volume of production increased only 50 per cent from 1919 to 1920 the value increased nearly fourfold, reaching the highest figure on record up to 1927. This condition reflects the excessively high prices that characterized the year 1920.

Maryland was the chief producer of diatomite in 1883, the output being used principally for manufacture of a polishing powder sold under the trade names "Electro-silicon" and "Eldorado polish." From that date to 1900 diatomite was produced in New Hampshire, Connecticut, Massachusetts, New Jersey, Virginia, Georgia, Alabama, Nevada, and California, but the output was small as the uses were quite limited. It was employed principally as an abrasive and as an absorbent for nitroglycerine in the manufacture of dynamite.

The latter use has become of little importance, and the popularity of synthetic polishing powders has prevented any material growth in production of natural abrasives. The heat insulating properties of diatomite were early recognized, and its uses for boiler, pipe, and furnace coverings have greatly increased. Other uses as in fireproof building materials, plasters, fillers, and as a filtering medium were gradually developed. The famous deposits at Lompoc, Calif., first came into prominence in 1902, and in 1904 California became the leading producer. The purity of the Lompoc material, and its availability in either block or powdered form encouraged intensive development, and from the year 1907, California dominated the industry. Filter blocks and insulating brick cut from the more firmly consolidated ledges were added to the variety of products, and filtration uses were greatly enlarged.

A noteworthy event in the history of diatomite production was the sudden expansion when the output leaped from 2,965 tons in 1918 to 42,642 tons in 1919. This was due in part to its extensive use for filtration and insulation, and in part to the general overstimulation of industry that culminated in the high peak of 1920. It is significant, however, that the wide use established in 1919 has been maintained and increased, more than double the amount being sold in 1926 than was sold in 1919. The industry has been so largely in the hands of one company that definite figures subsequent to 1926 are unavailable.

The tripoli industry was of small importance until development of the deposits at Seneca, Mo. They were first worked in 1887, and attained importance in 1892, furnishing material for filter blocks and for soaps and polishes. In later years the larger part of the Missouri output was used for fillers, foundry facings, and in glass and pottery. Tripoli from Tamms, Ill., entered the field about 1907, and from Oklahoma in 1912. From that time until 1919 tripoli production far exceeded that of diatomite. The industry has experienced moderate growth since that date, although at a lower level than diatomite. From 1913, the first year for which figures are available by States, until 1922, Illinois produced about 60 per cent of the total output of the United States. Thereafter the proportion gradually decreased to about 34 per cent in 1929. The chief producing States in 1930 were Illinois, Missouri, and Oklahoma, with smaller production from Arkansas, Tennessee, and Georgia. The so-called "rottenstone," a more earthy siliceous product obtained in Lycoming County, Pa., is included with tripoli.

Feldspar

Partly kaolinized feldspar, according to some early records, was mined by the Indians in North Carolina and shipped to England for pottery manufacture as early as 1744. Statistical records are available from the year 1880, but commercial production began at least 15 years prior to that time, for a flint and feldspar grinding mill was built at Trenton, N.J., in 1865. In 1883 six States produced a total of 14,100 tons, all of which was used in pottery except a small quantity of high-grade material from Delaware used in the manufacture of artificial teeth. Production was first recorded in Canada in 1890, in which year 700 tons were shipped.

In 1891 production in the United States was only 10,000 tons, and it was reported that deposits were scarce and that new discoveries were greatly needed. How assiduously our resources have been developed is evidenced by the fact that no difficulty is now experienced in obtaining more than 200,000 tons annually.

The year 1897 was characterized by a trend toward increasing output by fewer companies. About this time the use of feldspar in scouring soaps, wood fillers, and as a glass constituent had attained some prominence. As may be observed in Table 4, production value increased almost sevenfold from 1898 to 1899. The figures are probably not a true measure of growth, because tonnage simply doubled in that period (13,440 tons in 1898 and 27,202 tons in 1899). It is probable that much of the value for the latter year was that of ground spar. Prior to 1901 figures for value of production are uncertain and conflicting, but from that year they are much more dependable because double counting has been avoided and the value of spar entering trade in ground form, is calculated on the basis of prevailing prices for crude spar.

From 1901 growth of the industry was rapid, production in 1903 reaching 41,891 tons and in 1911, 92,700 tons. There was a 30 per cent decline in production in 1918 as compared with 1917 because pottery manufacture, not being regarded as essential during the war period, was at a very low ebb. However, the decline in quantity was compensated to some extent by higher prices. Production declined further during the following three years, but prices continued to rise. The 1920 boom in business overstimulated the production of feldspar, and the depression which followed resulted in a great shrinkage in demand at a time when stocks accumulated during the boom were excessive. Since 1923 annual production has averaged about 200,000 tons. The year 1925 was noteworthy because of a merging of companies and of an increasing cooperation between producers and users.

Beginning about 1920 milling capacity increased so rapidly that an acute situation was reached in 1929, when it was estimated that the mills then in operation were capable of grinding at least twice the normal annual amount consumed. In 1931 production of ground spar amounted to only about 30 per cent of total grinding capacity.

The United States has become an increasingly important factor in world production. In 1912, of the total production of all the leading countries the United States produced 38 per cent, Norway 19, Sweden 17, Italy 17, Canada 6, and Germany 3. In 1929 United States production had increased to 61 per cent of the total, while Sweden produced 12 per cent, Canada 11, Norway 8, France 4, Italy 2, and Germany 2.

Production has been centered chiefly in the Appalachian district of eastern United States. Connecticut was the principal producer in 1883 and for a number of years thereafter. Pennsylvania stood second, and other producers were Maine, Massachusetts, Delaware, and New York. Maryland was first recorded as a producer in 1896. Pennsylvania took the lead in output in 1900. Virginia and Minnesota were added to the list of producers in 1907, California in 1909, North Carolina in 1911, Vermont in 1912, and Georgia in 1916.

In 1915 New Jersey and Ohio attained prominence, not as producing States, but because feldspar grinding had attained importance in the notable ceramic centers of Trenton, N.J., and East Liverpool, Ohio.

The most remarkable geographical change in the industry was the rapid growth in North Carolina. While not recorded in the list of producers until 1911, the State reached first rank in 1916. By 1921 it dominated the industry, and subsequently has produced from 40 to more than 50 per cent of the entire United States supply. Since North Carolina became the leading producer it has yielded its supremacy for only one year, to Maine in 1920.

Arizona first began production in 1923 and South Dakota in 1925, the latter State attaining considerable importance in 1928. In that year North Carolina became the leading feldspar grinding State, although its first grinding mill was erected only in 1922.

The early mining of feldspar was in small irregular open pits along pegmatite dikes. First reference to underground mining was in 1907 when the workings at Pomeroy, Pa., were briefly described. Other underground operations followed, some of which were extensive. Loading by hand methods is almost invariably employed, although in one open-pit quarry in North Carolina, power-shovel loading was introduced in 1929.

Evolution in milling was slow until recent years. In the first mills hand-sorted spar was ground with buhrstones and pulverized in batch ball mills using flint grinding pebbles. The first coarse grinding was done with "chaser mills" which consisted of pairs of stone wheels about 6 feet in diameter running in a circular track with a stone floor. Such equipment is still used in a few mills. In 1907 a long step was made in technique by the introduction in one Connecticut mill of a gyratory crusher, steel crushing rolls, and continuous-feed tube mills. The greatest advances in milling have been made since 1925 by the introduction of air-swept tube mills, compressed-air conveyance of ground spar, improved vibratory screens and air separators, magnetic separators to remove impurities, and better control of both composition and grain size.

The first movement toward standard specifications was noted in 1906 when feldspar was classified as No. 1, No. 2, and No. 3. However, little progress in grading was made for many years. Many consumers designated the kind of spar they desired simply by its geographic source - as, for example, Maine spar or Connecticut spar. In 1922 serious efforts were made toward selection of spar by chemical composition and definitely limited content of impurities. This movement gained impetus in succeeding years, and in 1928 a long stride was made toward technical control of quality by means of careful chemical analysis, by segregation of varieties according to composition, and by blending to obtain a product of desired composition. The movement toward improved and dependable quality culminated in 1929 in conferences between producers, grinders, consumers, and technical advisors at which a new classification of feldspars was agreed upon.

The growth of the feldspar industry is to be attributed mainly to increase in ceramic manufacture, for its chief use has always been in this field. In 1896 it was discovered that alumina was a valuable constituent of glass, and as feldspar contains other advantageous constituents - namely, the alkalies, soda, and potash - a new and important market was opened up. In 1907 feldspar was first used in any considerable quantity as a binder in abrasive wheels. Between 1900 and 1910 granular feldspar was used much more extensively for poultry grit and roofing granules than it is to-day. In 1919 about 20 per cent of the total production was so used, whereas in 1930 the amount was less than 4 per cent. Much interest has been manifested at various times in feldspar as a source of potash, but none of the numerous processes invented has ever attained commercial importance. Its use in scouring soaps and other abrasives was important as early as 1906; a deposit in Minnesota was mined exclusively for this purpose for several years subsequent to that date. A small quantity of high-grade "dental" spar has been used since 1883 for manufacture of artificial teeth.

The proportions of feldspar applied to various uses in 1913 and 1930 are contrasted in Table 7.

Table 7.- Sales of feldspar, by uses

Uses	1913, per cent	1930, per cent
Ceramics	85	57
Glass industries	1	30
Scouring soaps and abrasives	4	7
Binder for abrasive wheels	-	2
Poultry grit, roofing stucco, and other minor uses	10	4

Fluorspar

Fluorspar occurs in many States, but there are few places where it is found in sufficient quantity or in favorable location for commercial development. The mining of fluorspar apparently began at Trumbull, Conn., in 1837, when a small amount was sold at $60 a ton for use in smelting copper ores. It was first mined at Rosiclare, Ill., in 1842, but there were no shipments of commercial significance from that locality before 1870. Shipments were first made in Kentucky about 1871, but were of small importance prior to 1896. Thus the industry has consistently maintained the Illinois-Kentucky district as a center of chief production.

Production remained fairly constant at 4,000 to 8,000 tons a year from 1880 to 1898, but with the growing appreciation of the value of the mineral in metallurgy, together with the great expansion in steel production, it increased rapidly from that date, reaching 48,000 tons in 1902 and more than 57,000 tons in 1905. The years 1910, 1911, and 1912 were marked by a great increase in production, which attained a volume of more than 116,000 tons in the latter year. War demands led to a phenomenal output of nearly 260,000 tons in the peak year, 1918. Except for two low points, 1921 when production reached only about 35,000 tons and 1931 when it dropped to about 53,000 tons, production since the World War has ranged from 112,000 to 146,000 tons per year. Values from year to year are shown in Table 4.

Prices have followed in a general way the curve of production. Annual average values ranged from $4 to $8 a ton from 1880 to 1916; war conditions forced them to a peak of $25.50 a ton in 1918; and since the war prices have ranged between $18 and $20 a ton.

Except for a small production in Kentucky in 1886 and 1887 Illinois was the sole producing State of any consequence until 1896, in which year mines were developed at Marion, Ky. Kentucky was the chief producer from 1898 until 1905, when Illinois again took the lead and maintained it except in 1921 and from 1926 to 1929, during which years Kentucky again headed the list. These two States have together produced a very large percentage of total supplies. Of the other States, Colorado has been a steady producer since 1905, providing from a few hundred tons a year to a maximum of 38,000 tons in 1918. New Mexico began production in 1909 and has been a fairly consistent producer, furnishing 1,000 to 6,000 tons a year for most years since that date. New Hampshire provided a small supply from 1911 to 1923. Arizona, Nevada, Tennessee, Utah, and Washington have been small producers at irregular periods. Some concern has been felt at times regarding future reserves, but it seems probable that mines now or recently in operation can supply all reasonable demands for many years, although at an increasing cost.

Importations have always exerted a marked influence on the domestic fluorspar industry, for they have competed effectively with Illinois-Kentucky products on the Atlantic coast and have practically fixed prices as far west as Pittsburgh. By 1908 imports had attained a volume of about 20,000 tons a year, and a duty of $3 a long ton was imposed in August, 1909. The tariff had no visible effect on imports, which increased to over 42,000 in 1910 and continued at a level exceeding 20,000 a year until 1913, when the duty was reduced to $1.50 a ton. In 1922 it was increased to $5.60 a ton, and, curiously enough, during the year following this increase, imports expanded to more than 42,000 tons. England was the chief source of foreign supply until 1927, when Germany took the lead. In 1928 the duty was advanced from $5.60 to $8.40 a long ton for material containing not more than 93 per cent calcium fluoride, and under the tariff act of June 18, 1930, this rate was extended with respect to fluorspar containing not more than 97 per cent calcium fluoride. During the years following 1926, Germany, France, Spain, and the Union of South Africa assumed increasing importance as sources of supply, and imports from these countries competed keenly with the domestic product.

The mineral cryolite is intimately associated with the fluorspar industry because the two minerals are employed in much the same way and because fluorspar is used in the manufacture of artificial cryolite. The natural mineral is apparently preferred for certain uses and has been imported from Greenland for a great many years in amounts ranging usually from 2,000 to 5,000 long tons a year.

The earliest use of fluorspar, except possibly for ornamental purposes, was in the metallurgical industries; Agricola noted its use as a flux in 1529. The use of fluorspar as an ingredient in opaque glass and enamel and for the manufacture of hydrofluoric acid and other chemicals has been important almost from the beginning of the industry. Until about 1898 the greater part of the production was apparently used for apeque glass manufacture, but subsequently metallurgical uses predominated. The earliest metallurgical uses were in foundry work and in the smelting and refining of nonferrous ores and metals. Its use in open-hearth steel making was first mentioned about 1903, but with rapid growth in that process such use speedily became dominant and has for many years consumed from 75 to 85 per cent of the entire supply. Since the period when the open-hearth steel furnace attained its full development there have been fluctuations in the relative amounts of fluorspar used for different purposes from year to year, but certain definite trends are evident. Of prime importance is a gradual decrease in the number of pounds of fluorspar used per ton of steel manufactured by the open-hearth process. Increasing use in the chemical industries and decreasing use in foundries are likewise noteworthy. It is difficult, if not impossible, to find satisfactory substitutes for fluorspar for most of its uses; therefore an adequate supply, either domestic or imported, is to be regarded as essential to industry.

Table 8.- Production value of certain minor nonmetallic minerals, 1880 to 1931
(Recent annual production less than $10,000,000)

Year	Fuller's earth	Graphite	Magnesite (crude)	Mica	Potash salts	Talc & soapstone
1880	-	$ 49,800	-	$127,825	-	$ 121,395
1881	-	30,000	-	250,000	-	135,000
1882	-	34,000	-	250,000	-	165,000
1883	-	46,000	-	285,000	-	225,000
1884	-	35,000	-	368,525	-	310,000
1885	-	26,231	-	161,000	-	310,000
1886	-	33,242	-	80,000	-	350,000
1887	-	34,000	-	148,250	-	385,000
1888	-	33,000	-	70,000	-	460,000
1889	-	72,662	-	52,450	-	475,878
1890	-	77,500	-	78,900	-	641,505
1891	-	110,000	$ 4,390	100,000	-	737,049
1892	-	87,902	10,040	100,000	-	909,934
1893	-	63,232	7,040	1/88,929	-	658,503
1894	-	64,010	10,240	52,388	-	836,385
1895	$ 41,400	52,582	17,000	55,831	-	637,392
1896	59,360	48,460	11,000	67,191	-	753,508
1897	112,272	65,730	13,671	95,226	-	762,565
1898	106,500	75,200	19,075	131,098	-	698,542
1899	79,644	167,106	18,480	101,465	-	768,955
1900	67,535	197,579	19,333	147,960	-	883,041
1901	96,835	167,714	10,500	118,578	-	908,488
1902	98,144	182,108	8,490	118,849	-	1,140,507
1903	190,277	225,554	10,595	143,128	-	840,060
1904	168,500	321,372	9,298	120,316	-	940,731
1905	214,497	318,211	15,221	178,588	-	1,082,062
1906	265,400	340,239	23,415	274,990	-	1,431,556
1907	291,773	296,970	22,683	392,111	-	1,531,047
1908	278,367	208,090	19,761	267,925	-	1,401,222
1909	301,304	345,509	37,860	280,529	-	1,221,959
1910	293,709	335,443	74,658	337,097	-	1,592,393
1911	383,124	288,465	75,000	355,804	-	1,646,018
1912	305,522	220,583	84,096	331,896	-	1,706,963
1913	369,750	293,756	77,056	436,060	-	1,908,097
1914	403,646	324,118	124,223	329,956	-	1,865,087
1915	489,219	429,631	274,491	428,769	$ 342,000	1,891,582
1916	706,951	935,471	1,393,693	594,391	4,242,730	2,253,803
1917	772,087	1,167,879	2,899,818	806,782	13,980,577	2,292,878
1918	1,146,354	1,524,254	1,812,601	764,940	15,839,618	2,681,019
1919	1,998,829	778,857	1,248,415	541,651	11,271,269	2,352,675
1920	2,506,189	626,202	2,748,150	713,989	7,463,026	3,035,449
1921	1,973,848	96,524	510,177	175,362	447,859	1,755,942
1922	2,289,719	2/ 85,242	571,745	308,346	463,512	2,859,897
1923	2,247,523	190,994	1,103,700	440,875	784,671	3,012,253
1924	2,632,342	87,510	1,041,300	299,277	842,618	3,515,556
1925	2,923,965	96,361	1,432,700	495,499	1,204,024	3/ 2,011,793
1926	3,356,482	219,342	1,200,830	536,827	1,083,064	3/ 2,110,994
1927	3,767,038	232,971	1,090,550	322,621	2,448,146	3/ 2,234,724
1928	3,895,991	297,093	1,098,550	363,378	3,029,422	3/ 2,537,994
1929	4,309,723	310,891	1,500,000	404,222	2,988,448	3/ 2,628,662
1930	4,326,705	4/ 20,525	1,033,130	286,407	2,986,157	3/ 2,108,338
1931	3,055,570	(5)	499,239	211,245	3,086,955	3/ 1,852,472

1/ Sheet mica to 1892. Sheet and scrap beginning 1893.
2/ Figures for crystalline graphite only.
3/ Figures for talc only.
4/ Figures for amorphous graphite only.
5/ Bureau of Mines not at liberty to publish figures for graphite in 1931.

Fuller's Earth

Fuller's earth is a claylike substance named from its ability to absorb grease and oil from cloth and wool, properties which were known in the Middle Ages. For many years small imports were obtained from England to satisfy the limited needs of the United States. In this country the first State to produce fuller's earth was Arkansas, which had a small output in 1891. With the discovery of the extensive Florida deposits in 1893 domestic production increased rapidly for a few years, going from 6,900 tons in 1895 to 17,000 tons in 1897. From 1899 to 1902, inclusive, growth of the industry was slow because imported English earths were low in price and of high quality. From 1903 the wider use of petroleum demanded rapidly increasing quantities of fuller's earth. Production grew from 20,000 tons in 1903 to over 40,000 tons in 1911, and the increase in output was accelerated with the stimulation of war demands until it exceeded 84,000 tons in 1918, 106,000 tons in 1919, and 128,000 tons in 1920. While many mineral commodities attained their maximum production in 1920, fuller's earth reached its peak in 1930, the output of that year exceeding 335,000 tons. The reason again is to be found in the enormous growth of the petroleum industry. A drop of 14 per cent in tonnage in 1931 represents the most serious decline since 1921. Certain bentonites and other clays differing in character from ordinary fuller's earth but coming into use in the same way assumed considerable importance subsequent to 1927 and have therefore been included in the statistics since that year.

The value of production shown in Table 8 followed in general the volume of output, but with two notable exceptions. Value attained in 1920 a higher peak than tonnage, because prices of fuller's earth in common with other products were abnormally high that year. The second divergence was from 1928 to 1930 when the price per ton declined while volume reached a high level -- a condition approaching "profitless prosperity."

Fuller's earth production has been preeminently a southern industry. Alexander, Ark., where a small amount was obtained for oil refining in 1891, is claimed as the locality where the earth was first produced in the United States but production in volume originated at Quincy, Fla., where large deposits were discovered in 1893. Florida was the leading producer until 1924, when Georgia, which had been an important producer since 1907, took the lead. The early Arkansas industry died out, was revived in 1901 to importance for several years and finally became dormant again in 1922. Alabama and Massachusetts began to produce in 1904, South Carolina and Texas in 1907, California in 1909, Nevada in 1918, Illinois and Pennsylvania in 1922, and Arizona in 1927. Colorado, Idaho, Maryland, Minnesota, Mississippi, Missouri, Montana, New York, Utah, Virginia, and Washington are also producers or have produced at times. The Southern States, notably Georgia, Florida, and Texas, have produced each year from 75 to 99 per cent of the total.

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Small imports, ranging from 200 to 800 tons a year were obtained from England, the sole source of foreign supplies, from 1867 to 1882. In 1883 imports exceeded 1,200 tons and by 1899 had grown to 10,000 tons a year. A maximum of nearly 25,000 tons was attained in 1914, and thereafter imports gradually decreased to a minimum of a little over 4,000 tons in 1931.

In 1913 the duty was reduced to 75 cents a long ton for unmanufactured, and $1.50 a ton for wrought and manufactured fuller's earth, but this duty was increased to $1.50 and $3.25, respectively, in 1922. No further change was made in the tariff act of 1930. Since production was first recorded in 1895, imports have exceeded domestic output in one year only, 1902. From that time the proportion has gradually diminished until during recent years it has reached not more than 1 to 3 per cent of domestic production. Therefore imports are not an important factor in the fuller's earth industry.

For centuries the sole use of fuller's earth was in cleansing (fulling) cloth, wool, and fur, but its ability to clarify animal and vegetable oil was later recognized. Prior to the early nineties imported fuller's earth was used for the latter purposes, while mineral oils were purified with bone black, but with the beginning of its production in Florida, fuller's earth replaced bone black in petroleum clarification. From that time onward the principal use of fuller's earth has been the bleaching, clarifying, or filtering of fats, greases, and oils.

As a result of an inquiry instituted in 1918 it was found that all imported earth was used for vegetable and animal oils and fats, whereas the domestic output was used for mineral oils. Many users are favorably disposed toward English earth for edible oils, but subsequent to the World War domestic earths have been used for this purpose in increasing amount. During recent years 90 to 95 per cent of domestic earths are used for the treatment of mineral oils, from 3.5 to 8.5 per cent for vegetable and animal oils, and 1 to 2.5 per cent for miscellaneous uses. Its use in fulling cloth has practically ceased.

The revification of fuller's earth, a calcination treatment whereby used material is made suitable for reuse, although known for many years, attained importance only since 1920. During the same period the acid treatment of certain bentonites and other earths, unsuited for use in their natural state, has gained some prominence.

Fuller's earth and related clays are essential to the petroleum industry, and no substitutes are now available. Therefore a substantial output comparable with or in excess of that produced in recent years is to be expected in the future.

Graphite

Graphite has been used as a coloring agent for many centuries. The earliest names, "plumbago" and "black lead," record the prevalent though erroneous idea that it consisted of or at least contained lead. One of the earliest uses, as the name "graphite" implies, was for writing, a use that dates far back in the Middle Ages. It was first used in the form of fragments or crayons, and later with a wooden covering - the well-known lead pencil.

Graphite mining in the United States has been one of the most disappointing of the mineral industries. There are large domestic resources of flake graphite, but production costs are relatively high because the deposits are generally lower in grade than those in Ceylon or Madagascar. This has always tended to make it difficult for domestic producers to meet foreign competition on a cost basis, but the main obstacle has been to induce consumers to use the American product even at a much lower price than they are willing to pay for imported graphite.

Production in the United States began in New Hampshire as early as 1927, the product being used for manufacture of crucibles, but no statistical records are available prior to 1880. In that year production was recorded at Ticonderoga N.Y., of a crystalline graphite suitable for crucible manufacture. New York continued as the principal producer of this variety of graphite for many years. The Alabama deposits, which were known from 1875, began production about 1912 and attained importance from 1916 to 1920 under the stimulation of war demands. Crystalline graphite has been produced not only in New York and Alabama, but also in Texas, Montana, Pennsylvania, New Jersey, and Georgia. Supplies of amorphous graphite in Michigan, Nevada, Wisconsin, Rhode Island, and other States are large, and, on a tonnage basis, production of amorphous greatly exceeds that of crystalline graphite.

As may be observed from the figures in Table 8 showing value of domestic production, there was little growth prior to 1899. In that year production value was more than double that of the preceding year, and this high level was maintained and gradually increased to nearly $500,000 in 1915. Under the stimulus of war demands there was a notable increase during 1916, 1917, and 1918, followed by a rapid decline, the enormous stocks accumulated during the latter part of the war practically paralyzing the producing industry until 1923. It was not until 1926 that recovery had reached a point comparable with the prewar condition, and even the high level of industrial activity in 1929 failed to stimulate a volume of production equal to that of 1914.

Imports have always exceeded domestic production by a wide margin. Graphit was first obtained in Ceylon in 1827, and by 1882 imports of graphite into the United States exceeded 16,000,000 pounds a year. By 1899 they had attained a value of nearly $2,000,000, more than 10 times the value of domestic production. To satisfy the demands of the war they attained a maximum of nearly $9,000,000 in 1917, but, because of the shortage of shipping, imports fell precipitously, and by 1921 they were a mere fraction of the high figure attained in 1917.

With foreign supplies thus greatly reduced the domestic industry was stimulated to take care of manufacturer's needs, but production suddenly declined in Alabama in 1919, 1920, and 1921, and imports gradually increased, exceeding the million dollar mark in 1929. Ceylon has been the chief source of foreign supply, but since 1912 shipments from Madagascar (partly via France) have become an increasingly large factor. Mexico is an important source of amorphous graphite and Canadian mines find their main market in this country.

In 1922 a duty of 10 per cent ad valorum on amorphous, 20 per cent on crystalline lump, chip, and dust, and 1½ cents a pound on crystalline flake was imposed. The tariff act of 1930 increased the rate on lump, chip, and dust to 30 per cent, and on flake to 1-65/100 cents a pound.

Manufactured graphite has exerted an important influence on the industry. First produced in quantity in 1898 its output amounted to more than 2½ million pounds in 1901, more than 6½ in 1907, 13½ in 1913, and nearly 27 million pounds in 1923. During a majority of the years since 1910 production of manufactured graphite has exceeded the combined output of domestic amorphous and crystalline graphite. Manufactured graphite competes directly with natural graphite for almost all purposes, except perhaps crucible manufacture.

Evolution in the uses of graphite is noteworthy. Crucible manufacture, which consumed 55 per cent of the total in 1903, required only 13 per cent in 1924. This is due no doubt to a declining use of graphite crucibles for melting metals. Stove polish, which consumed 32 per cent of the total in 1884, required only 1.5 per cent in 1924. On the other hand, foundry facings, which used 10 per cent in 1903, required more than one-half of the total supply in 1924. The general trend is toward an increasing use of the lower-priced grades and a declining consumption of the more costly varieties, for it has been found that for many applications the cheaper types can be substituted successfully for the higher grades.

The graphite mining industry throughout the world has been in a depressed state for several years due not only to the general recession in business and manufacturing, but also to the tendency to find substitutes for natural graphite, and to modify processes so that the desired results are attained without the use of equipment employing graphite. Crucible steel manufacture, formerly an important outlet for graphite crucibles, is practically obsolete, especially in the United States, and other metals are being melted more and more by processes employing no graphite-clay containers. Even for the manufacture of dry batteries the demand for natural graphite has suffered on the one hand from increasing use of manufactured graphite, and on the other hand from the use first of storage batteries for automobile ignition and radio operation, and later of light socket power for radios. To the domestic mining industry, never a profitable one, is added the further handicap of competition from relatively low-cost foreign graphite which enjoys more favorable consumer acceptance as compared with the domestic product.

Magnesite

The term "magnesite" was first restricted to the natural carbonate of magnesia in 1808. The first important use of the mineral was for manufacture of a plastic cement invented by Sorel in 1867, but magnesia cement was not used extensively prior to about 1913. Magnesite has been applied to refractory uses in Europe since 1884. The use of California magnesite for magnesia cement was first mentioned in 1888, and it was first used for lining furnace bottoms in 1891.

The geographic location of commercial deposits has had a profound influence on the development of the magnesite industry. While occurrences of the mineral have been noted in many States production has come almost entirely from California and Washington. Thus the industry has always been handicapped by heavy freight charges to the larger consuming centers.

The first authentic record of production dates from 1891, when the output was valued at a little more than $4,000. As may be noted from Table 8, there was very little growth in the industry prior to 1905. The needs of the Pacific Coast States were limited, and heavy freights prohibited marketing east of the Mississippi River. Subsequent to 1905 there was some expansion, but imports dominated the consuming industries, and there was no notable growth until war demands gave great impetus to production in 1915. As the eastern United States had been dependent upon foreign countries for its furnace linings the cessation of imports, combined with greatly increased steel production, led to a phenomena development of the industry on the West coast, production increasing from 11,00C tons in 1914 to nearly 155,000 tons in 1916 and to more than 316,000 tons in 1917. Large quantities were shipped to eastern furnaces under freight rates reaching $10 to $12 a ton. Oversupplies, coupled with the termination of the war, led to a reaction in 1918 and 1919, but with continued steel production at a high level, and small imports, a great increase in production recurred in 1920. Large stocks, the prospect of increasing imports, and a tendency in some localities to use dolomite instead of magnesite led thereafter to the most pronounced decline in the history of the industry, a drop from more than 300,000 tons in 1920 to less than 50,000 tons in 1921. It is noteworthy, however, that the industry has since 1923 maintained a production of over $1,000,000 in value per year, which is far above the pre-war level. The maintenance of this volume of output is due in large measure to a protective tariff imposed in 1922 and increased in 1927.

For many years California was the only producing State. The Stevens County, Wash., deposits, first developed in 1916, provided one-third of the domestic output in 1917, more than 60 per cent of it in 1918, and nearly 80 per cent in 1920. Since the World War, production has been divided between California and Washington.

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Foreign supplies have had a pronounced effect on the industry. Prior to the World War imports were 18 to 20 times as great as domestic production. Such a condition was inevitable because the great steel centers with their heavy demands for refractories were in the East where no domestic supplies were available and where Austrian and Grecian magnesite could be readily procured. Cessation of imports led to the phenomenal increase in production on the West coast during the war. During the postwar period imports have been little in excess of domestic production; since 1928, in fact, United States production has exceeded imports by a considerable margin.

Some noteworthy changes have taken place in the uses of magnesite. In general it may be stated that its use as a refractory has always predominated, but until recent years the domestic output, through force of circumstances, was largely diverted to other uses. For many years the California product was calcined for production of carbon dioxide gas and for application of the calcined residue to sulphite paper manufacture. Thus the output was restricted to the needs of the paper industry on the West coast. The substitution of dolomite and high magnesian lime at paper mills led to a rapid decline in this use, the replacement being practically complete by 1915. The moderate expansion from 1905 to 1914 was due largely to increasing use for plastic flooring, artificial stone, insulating materials, molded building units, and magnesium salts. During the war period a very large proportion of the California and Washington output was used for refractory manufacture; subsequently, under tariff protection, dead-burned magnesite has been the principal product, the use of caustic calcined magnesite decreasing due to a declining use in stucco, artificial stone, and similar building materials.

Dolomite as a competing mineral has had a marked influence on the industry. Dead-burned dolomite was employed for furnace linings in Pittsburgh as early as 1891, and dolomite was used as a source of magnesia for insulating material in Milwaukee as early as 1905. Lack of local supplies of magnesite in the East and shortage of imports during the World War led to a much wider use of dolomite as a refractory, and many furnace operators continued its use wherever possible because of its low cost. Therefore a postwar trend is to be noted toward a wider use of dolomite for carbon dioxide manufacture, for the sulphite-paper process, for refractories, and for technical carbonate, although magnesite is still generally used for manufacture of plastic flooring. For the principal uses mentioned above an amount varying from 1,000,000 to more than 1,500,000 tons a year of dolomite has been used since 1918.

The magnesite industry has been peculiarly unfortunate in retaining its markets in competition with other products. Dolomite is only one of the substitute materials. In building construction Portland cement and various other cementing and flooring materials have drastically curtailed the use of magnesite products. The relatively high price of magnesite refractories since 1922 has encouraged the substitution of cheaper materials, notable chromite. The present magnitude of the domestic industry is directly dependent upon tariff protection, but the tariff in this instance has proved a mixed blessing by cutting down the gross demand for magnesite as well as defending a share of the market for the benefit of domestic miners.

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Mica

Ancient excavations for mica in North Carolina attributed to the mound builders are said to represent the earliest evidences of mining in America. Commercial mica mining began in Grafton County, N.H., in 1803. While the industry attained considerable importance in early years it has registered little real growth. As may be noted in Table 8, the value of production in 1884 was just about the same as in 1928; for many of the intervening years it was much lower, and for a few years only was it higher.

Early production consisted principally of large sheets used in stove and furnace doors and for windows. The latter use perhaps antedates the manufacture of glass. The contraction in value of output which began about 1886 and continued until 1899 was due in some measure to a change from larger to smaller sizes of stove mica, also to poor methods of mining and preparation and to increased imports. From 1900 to 1905 the use of the smaller sizes of domestic mica in the electrical trades stimulated production to some extent. The years 1905 to 1915 were characterized by a great increase in volume, though a very moderate increase in value, as shown in Table 8. Much of the output consisted of punch and the smaller sizes of sheet mica which command a low price per pound. Even the requirements of the war period stimulated only a small physical increase in domestic production. Subsequent to 1922 volume of production has attained higher levels than it did during the war, although the value has been lower. Of sheet mica, including splittings, the United States produces only 25 to 35 per cent of its requirements.

As only a small percentage of all mica mined can be classed as commercial sheet, accumulations of scrap are very large, and the marketing of scrap mica for grinding purposes has enabled many producers to maintain a profit. Thus whatever small degree of prosperity the mica industry has experienced is due in considerable measure to an increasing market for scrap.

Prior to 1867 the entire United States production of mica was obtained from New Hampshire. In that year North Carolina became a producer and subsequently, with few exceptions, has been the most important producing State. Many other States have produced at times. Amelia County, Va., was a source of sheet mica before 1870, mica was discovered in South Dakota in 1879, and there was a large production in 1883 and 1884. New Mexico first produced in 1884. Georgia, South Carolina, Alabama, and Idaho have at times attained production of commercial importance.

Evolution in uses has been an important factor in the history of the mica industry. Window glazing was probably the earliest use. Large sheets for stoves and furnaces were the chief products prior to 1888. The first notable change was from large to small sizes, and was followed by a gradual decline in glazing demands. The applicability of mica to electrical uses was known in 1888, but for many years little or no domestic mica was so employed. It was found, however, that if properly selected and prepared domestic mica was quite satisfactory for electrical equipment, and between 1900 and 1905 electrical uses became the most important of its applications. The production of diaphragm mica for telephones, phonographs, and similar instruments attained some consequence. When the extensive manufacture of radios subsequent to 1922 led to a decrease in phonograph use, this loss to the mica industry was more than compensated for by an increase in the demand for small condenser sheets used in radios. More than 90 per cent of all sheet mica is now used for electrical insulation. Built-up mica was first manufactured about 1901, and it has become an important branch of the industry.

Scrap mica, which constitutes 85 to 90 per cent of the entire domestic production, was waste material in early days, but its uses have greatly multiplied. As early as 1883 it was ground and used in a small way as a lubricant, as an explosive filler, and for decoration. Its employment as a decorative material in wall paper, now the most important use of high-grade ground mica, was first mentioned in 1890. Its use in roofing, fireproof paints, and many other products was of later origin.

From the beginning of the use of electrical machinery foreign mica has been extensively employed in American industry. India mica, first imported in 1884, has almost from the first been valued greatly above the domestic product. Imports of mica have been dutiable since 1890 and while the duties have been raised and lowered in subsequent tariff acts, the flow of foreign supplies has continued unabated. During the World War imports increased greatly. The peak of nearly $3,200,000 in value was reached in 1920, and was followed by a drop to about one-third of that amount in the next year. Imports since 1921, however, have been far above the pre-war level.

By far the larger part of the imports, both in volume and value, consists of splittings used in the manufacture of built-up mica. Even now the United States is almost entirely dependent upon foreign sources for this important product.

Recent investigations and tests have established the presence in the United States of many large deposits of high-grade mica. Most of the production, however, is from small mines that are lacking in equipment and that have no definite plans for enlarged future development. As the manufacture of splittings is a hand operation conducted by low-priced foreign labor, there is no prospect of the establishment of a domestic industry until such time as mechanical means for preparation of splittings are perfected. There are no domestic sources of supply of phlogopite (amber mica), which is preferred for commutator manufacture. It is obtained from Canada and from Madagascar.

Potash Salts

The potash salt producing industry in the United States has the shortest history of any important nonmetallic mineral commodity. Except for a widely-scattered production from wood ashes that attained some importance in 1850 and declined rapidly thereafter, there was little or no domestic production prior to 1915. The world's greatest known supplies of potash were in Germany, and the United States was entirely dependent upon foreign supplies for its needs. With outbreak of the World War foreign sources were cut off, and this condition, coupled with a greater need of fertilizers because of a greatly enlarged demand for food, created a critical situation. Every possible source of domestic supply was called upon, and each branch was stimulated to the utmost. The mineral sources were natural brines, alunite, cement-mill and blast-furnace dust, and, to a very small extent, silicate rocks. These sources were supplemented by organic potash from kelp, distillery and sugar-mill waste, wood ashes, and wool washings. From these sources production grew from a value of $342,000 in 1915 to more than $15,000,000 in 1918 (Table 8). However, the latter value is not a true measure of volume, because prices in 1918 were eight times as high as in 1913.

With post-war resumption of imports at prices lower than they were before the war, the domestic industry languished for some years. Even under difficult competitive conditions, however, production has grown from the low ebb of 1921 until since 1927 it has exceeded in quantity the output of the war years. This increase is due largely to the efficient operation of one plant utilizing natural brines at Searles Lake, Calif. Even with this increase imports have been three to six times as great as domestic production.

In 1910 the world's greatest known supplies of potash in Germany were placed under a rigid price-fixing and production control. This threat of absolute dependence upon one source of supply, and that in a foreign land, led to wide exploration by the United States Geological Survey and to research by the United States Department of Agriculture. Much experimental work was also done by other organizations or by private companies on greensand, alunite, and other potash-bearing minerals.

The first tangible result of exploration was the discovery in 1921 of potash salts in drillings obtained at oil wells in Texas. Evidence of the presence of potash at several points in Texas and New Mexico led in 1927 to a program of Federal core-drill exploration conducted jointly by the United States Bureau of Mines and the United States Geological Survey. As a result extensive beds of polyhalite were discovered, and the Bureau of Mines has made much progress in developing chemical processes for successful commercial treatment of this mineral. Contemporary core-drill exploration by a private company led to the discovery also of a large deposit of the water-soluble potash mineral sylvinite, and a mine sunk for its development near Carlsbad, N.M., came into production in 1931. In that year, for the first time in the history of the American potash industry, commercial production of potash from sylvinite was recorded. It appears, therefore, that the threat of unavoidable dependence on foreign supplies has been largely dispelled, and that the United States is on the threshold of a most important era in its potash mining.

Talc and Soapstone

Soapstone was used by the aboriginal inhabitants of North America for shaping into cooking utensils, tobacco pipes, and articles for religious ceremonies. Between 1870 and 1880 it attained considerable importance for the manufacture of tubs, sinks, hearthstones, mantels, griddles, fire brick, and various utensils. Talc for grinding was first quarried at Gouverneur, N. Y., about 1880, the fibrous talc of that district being used principally for paper manufacture.

The term "soapstone" has undergone changes in meaning that require definition before one can gain a true picture of developments in the industry. Not only were massive products called "soapstone" in early days, but the fibrous talc of New York State was termed "fibrous soapstone," and the industry as a whole was discussed in the literature under the heading "Soapstone" prior to 1900. In that year a distinction was made, the massive form being designated "soapstone" or "steatite," while material for grinding, and the ground product were called "talc." Prior to 1913 massive talcose rock which was shaped into tubs, bricks, crayons, or other articles consisting of either pure or impure talc was designated "soapstone," but from that year soapstone has been generally defined as an impure massive talc, the term "steatite" being used for the relatively pure massive mineral. The manufacture of block and ground products have always been considered as branches of a single industry designated "talc and soapstone." It is becoming more and more apparent, however, that they have little in common; some soapstones contain less than 10 per cent of talc and have little or no soapy feel. Soapstone production is, in fact, a branch of the dimension-stone industry, whereas talc production is more closely related to the production of clay, pulverized limestone, and other mineral fillers.

As indicated by figures for value of production shown in Table 8, the talc industry experienced an unusually steady and uniform growth with only moderate fluctuations prior to the World War, but, as in practically every industry, war conditions caused excessive changes. From a peak production of over 181,000 tons in 1916, output fell to about 107,000 tons in 1921. A quick recovery took place in 1922, and the industry thereafter maintained a high level of output, exceeding for the years 1927 to 1929 the pre-war peak. Production declined greatly in 1930 and 1931. During recent years the United States has produced from 45 to more than 50 per cent of the world output.

New York dominated the industry for many years, supplying more talc than all other States combined. Georgia, North Carolina, New Hampshire, Pennsylvania, New Jersey, Massachusetts, Maryland, Virginia, and Vermont were reported as producers in 1892, and they have continued as the principal producing States in the East. The industry has attained importance in Vermont, production exceeding that of New York in 1918, but New York again took the lead in 1923 and maintained it thereafter. These two States have for many years produced 70 to 75 per cent of the United States total. California began to produce in 1896 and Washington in 1904, but the great bulk of production has been in the East.

The original uses of talc as a filler in paper and paint, as a lubricant, and for toilet-powder manufacture have undergone little change, but many new uses have been added. The more important later uses are for foundry facings, roofing, electrical insulation, in ceramics, for rock-dusting coal mines, and as admixture in cement. Aside from growth in these newer applications the most noteworthy trend since 1921 is an increasing use in paints, a use that consumed nearly one-half of the total production in 1931. A small amount of massive talc has found uninterrupted use for crayon manufacture and for "lava" products.

Imports of talc have been relatively small, never exceeding 25 per cent in value of domestic production and for most years falling far below that amount. The principal products imported are the high-grade Italian and French talcs used for cosmetic manufacture. European talcs are generally preferred for cosmetics, although some domestic talcs, notably those from California, have been found suitable. Both cosmetic and filler grade talcs are imported from Canada.

While talc meets with competition from other pulverized materials for certain applications, its uses are firmly established. Its prosperity depends mainly on activity in the larger consuming industries, notably paint, paper, roofing, and rubber. Development of the newer uses may influence its future growth to quite an extent.

Small amounts of soapstone have been produced in various States, but almost the entire production has been from Virginia. The extensive deposits near Schuyler have been developed vigorously and the products have found markets throughout the nation and in foreign countries.

The primary uses of soapstone depended upon its easy workability and its property of resisting and retaining heat. Its resistance to chemical action led to wide use for lining retorts in paper mills, and for chemical laboratory equipment. With development of the electrical industries it was used for switchboards and panels. Prior to 1922 the manufacture of tubs and sinks was the major branch of the industry, but since the decline of this branch the greatest development has been in the building trades, notably for manufacture of interior trim, stair treads, floor tile, sills, spandrels, and other building units. Soapstone production outside of the United States is comparatively insignificant.